THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XLVIII.—*The Distribution and Origin of Drumlins;* by W. M. DAVIS.

The place of Drumlins in a geographic classification—Terminology—General Description—Distribution—Origin.

A CLASSIFICATION of geographic forms may be based first on general and special peculiarities of origin or structure, and second on degree of development by erosion. One could then group together plains, plateaus and their derivative forms under a name that would denote their formation from widespread horizontal layers; and this group could then be further divided according to the composition of the layers, as ordinary fragmental or calcareous strata of subaqueous deposit; as wind-carried dust deposits: as lava flows of igneous rock fed from below; as ice and snow fields of igneous rock from above; and finally as salt plains, the residue of evaporated lakes. All of these subdivisions could be again arranged according to their elevation and age, that is according to their geographic evolution under the destructive processes of time; there would thus be the new low plains, like those of Buenos Aires, still retaining their embryonic features; the adolescent plateaux in our west, of precocious development into forms of deeply incised drainage; the open, broken country of Kentucky, a matured derivative from an old plateau; the expanse of Central Russia, base-level plains of denudation that have returned in their second childhood to the nearly featureless forms of their youth; and so with many other examples.

A more complex group could include regions of disordered structure, characteristic of mountain ranges, but of very difficult subdivision. Here again it is of much importance to recognize the stage of destructive development, in order to mark the contrast between the new, still high and lake-bearing ranges like the Alps; the old, degraded and well-drained mountains like the Appalachians; and the low lands of denudation to which some of the older mountains have been reduced. A third group could bring together all intrusive igneous rocks such as dykes, necks, sheets (laccoliths), and masses; and a fourth would contain all local accumulations, where materials are heaped up on a relatively small base, as volcanic cones of ashes and lavas; æolian drifts, like sand dunes; and glacial drifts, such as moraines, drumlins and kames, which bring us to the special geographic form to be considered here.

It will be perceived that this grouping does not provide a definite place for topographic features of complicated history; it would be difficult, for example, to assign a place for the curved trap-ridges in our Triassic formations. This difficulty is inherent, for in the blending of inorganic forms we are not limited to crossing only between closely related forms as in the organic world; crossing, or double control of form occurs here even between the first structural divisions. Such blending will greatly complicate the resulting forms, and consequently only the simpler or more typical ones are here mentioned. A second cause of complication is found in the renewal of the cycle of development after a certain progress has already been attained; as is the case with polygenetic mountains, or with plains that have stood at different altitudes, like those of our west. But all these difficulties are outweighed by the increased attention and appreciation that physical geography gains when the origin and evolution of geographic forms are duly considered. Their meaning, individuality, and relations are then perceived with a clearness not otherwise attainable. As an illustration of a persistent form it is proposed to describe a kind or genus of smoothly rounded hills of glacial drift, that may be called drumlins. They belong among those elevations made by local accumulation of material by glacial action, on a foundation of other origin; they differ partly in structure and very clearly in form from other glacial deposits; being of relatively recent origin their constructional shape is still preserved, unless where cut by sea-shore waves or large streams, so that their evolution by erosion need not yet be discussed. Their name should be regarded rather as generic than as specific, for it will be shown that hills of somewhat varied form may be fairly included under this term.

TERMINOLOGY.—*Drumlin;* M. H. Close, Notes on the general glaciation of Ireland; read in 1866; Journ. Roy. Geol. Soc. Ireland, i, 207. A word of Irish derivation, meaning a long rounded hill. Most of the following terms are essentially synonymous with it, although some have a more specific meaning.

Parallel ridges; Sir James Hall, Trans. Roy. Soc. Edinb., 1815, vii, 169.

Drums and *Sow-backs* of Scotland; J. Geikie, Great Ice Age, 1877, 13, 76.

Parallel ridges; N. S. Shaler, Proc. Bost. Soc. Nat. Hist., 1870, xi, 27.

Lenticular hills; C. H. Hitchcock, id., 1876, xix, 63. These two papers refer to hills of more oval form than those of Ireland.

Whalebacks in New Brunswick; G. F. Matthew, Geol. Survey Canada, 1877–78, 12EE. These are not clearly separated from hills of stratified gravel.

Parallel drift-hills; L. Johnson, Trans. N. Y. Acad. Sci., i, 1882.

Mammillary or Elliptical hills; T. C. Chamberlin, Geol. Wisconsin, 1883, i, 283. Some of these have an almost circular base.

Of these several terms, drumlin appears by far the best in being a name, not a description; in having in English at least no other meaning than the technical one here adopted; and in having been proposed by the author who first gave a sufficient clue to the origin of these hills. It does not seem worth while to coin a word, as botanists and zoölogists are forced to do, for already a number of local names from various languages have come into general use in geography, as pampa, selva, steppe, tundra, atoll, delta, mesa, cañon, moraine; and drumlin may be well added to the list. Drumlins, using the term in its general sense, may be specifically qualified as long, oval or round.

General description.—Drumlins are hills composed of compact, unstratified glacial drift or till; their form is usually elongate or oval, with a ratio of horizontal axes varying from 6:1 to 1:1; the longer axis is parallel to former local glacial motion, as shown by neighboring striation or transportation of bowlders; the profile is generally smoothly arched and commonly almost symmetrical; terminal slopes, 3° to 10°; lateral slopes, 10° to 20°; length, one-eighth to two or more miles; height, 20 to 250 feet above base. The general uniformity of outline in any single region is very noticeable; indeed the view from the summit of a commanding drumlin, in the center of a group, shows as characteristic a landscape as that seen in looking from the Puy de Dôme over the extinct volcanoes of

Auvergne. Moreover, the control that drumlins exercise over the laying out of roads and the division of property is so complete in districts where they abound, that it is the rule to find roads, fields, gardens and even houses oriented in obedience to the march of the old ice invasion. About Boston, there are hundreds of dwellings whose walls thus stand in close parallelism with the glacial scratches on the bed-rock beneath them. In a recent number of *Science*, I have given several sketches of these drift-hills.

Distribution.—The absence of drumlins in non-glaciated regions confirms the evidence that gives them a directly glacial origin. When found, they occur either scattered about without apparent system, or crowded together in groups. The most extensive group of which I have a map is in northwestern Ireland, the district described by Kinahan and Close in their paper on the General Glaciation of Iar-Connaught, Dublin, 1872. The direction of neighboring glacial striæ is shown by arrows, which although not all parallel to one another, are strikingly parallel to the nearest drift ridges. These long drumlins "consist of stiff unstratified bowlder clay, containing well blunted and scratched stones and blocks; they have been most unquestionably formed by the rock-scoring streams [of ice], since they are, with very rare accidental exceptions, always parallel to the striæ near them" (op. cit., p. 6). They occur plentifully elsewhere in Ireland (Close), and in Scotland (A. and J. Geikie), and are well shown on some of the shaded one-inch maps of the Ordnance survey; but I have not been able to identify them satisfactorily in descriptions of the drift of Scandinavia, Germany or Switzerland. Erdmann's "Exposé des formations quaternaires de la Suede" (Stockholm, 1868) may perhaps refer to drumlins on p. 24 . . . "dans les plaines, ces masses de gravier (bowlder clay) s'élèvent en nombre considérable des couches d'argile environnantes, sous forme de collines plus ou moin grandes." Desor did not include them as characteristic features of his "Paysage morainique" (Paris, 1875). If occurring on the continent, they have not received the attention they deserve.

On this side of the Atlantic, they are common in many States. A fine group has been found in southeastern New Hampshire and the adjoining part of Massachusetts, which is represented on the geological atlas of the former State (1878). The group about Boston has been well described by Mr. Warren Upham (Proc. Bost. Soc. Nat. Hist., 1879, xx, 223). Corey's hill, the most northern of the group in the town of Brookline, is one of the best examples, and is well seen from the city looking westward up the Back Bay. A fine series of drumlins stretches from about Spencer, Mass., to Pomfret, Conn.,

but the detailed study that it would well repay has not yet been attempted. Members of this series occur near Charlton station, Boston and Albany railroad, with their bases at an elevation of 900 feet above sea-level, and others stand still higher. The portion of the group in Connecticut is described by Percival as follows. "The district extending north from Hampton, through Abington, Pomfret and Woodstock, is characterized by a series of very smoothly rounded, detached hills, in which the rock is usually entirely concealed. These form a striking contrast with the longer and more continuous [rocky] ridges of the adjoining formations" (Geol. Conn., 1842, 256: also 461, 479, 485). Prof. G. H. Stone reports that drumlins of large size, like those about Boston, have not been found in Maine. Western New York, between Syracuse and Rochester presents a surprising number of parallel, north-and-south drift hills, probably familiar to many travelers by rail. Some of them are so long, smooth and even that the country thereabouts has been described as *fluted*. These were long ago described by Prof. Jas. Hall in his Geology of the 4th district of New York (1843); since then they have been strangely neglected until examined by Dr. L. Johnson, who has lately published a paper entitled "The parallel drift-hills of Western New York" (Trans. N. Y. Acad. Sci., 1882, i, 77). Some of the ridges are "two or three miles long, and attain elevations of 100 or 200 feet above the intervening valleys; but the greater number are shorter and steeper. Many of them were, when first cleared of timber, very steep at their north ends, and on their east and west sides; but, with very rare exception, the southern slope is gradual." These and other irregularities of form may require that some of the hills of this region should be separated from drumlins as here defined. In Wisconsin, the drift-hills, as described by Prof. T. C. Chamberlin "are arranged in lines, and their longer axes invariably lie parallel to the movement of the ice. In some localities, especially in Dodge and Jefferson counties, these are mainly replaced by long parallel ridges, sometimes several miles in length, with corresponding linear marshes interspersed. These correspond accurately to the direction of ice motion." (Geol. Wisconsin, 1883, i, 283.) According to Mr. Upham, drumlins are not found in the abundant drift of Minnesota. A few examples are mentioned for Pennsylvania near its western border by Prof. Lewis. (2d Geol. Surv. Pa., Terminal Moraine, 1884, 29, 188.) It is evident enough from this review that the distribution of drumlins is insufficiently known.

Origin.—The earliest discussion of the origin of drumlins that I have found is in Sir James Hall's interesting paper on the Revolutions of the Earth's Surface (Trans. Edinb. Roy. Soc.,

1815, vii, 169). After describing the general form and structure of those about Edinboro', he says: "The facts seem to meet the challenge held out by Mr. Playfair in the following passage from his Illustrations of the Huttonian theory, art. 366. 'If there were anywhere a hill, or any large mass composed of broken and shapeless stones, thrown together like rubbish, and neither worked into gravel, nor disposed with any regularity, we must ascribe it to some other cause than the ordinary detritus and wasting away of the land. This however has never yet occurred, and it seems best to wait till the phenomenon is observed before we seek for the explanation of it.' Now it appears to me, that these vast assemblages, in which blocks of every size, and shape, and quality, some sharp, some round, are confusedly scattered through clay, are inexplicable by any diurnal cause, and do call for some particular solution" (p. 174). Sir James consequently decided in favor of earthquake waves as a means of forming drumlins: he recognized that the ridges of compact clay were parallel to one another (p. 177), and to the scratches on the bed rock below (p. 183), and considered vast diluvial waves competent to produce all these effects. Others of the older geologists have since then ascribed drumlins to the rush of diluvial floods; but it is noteworthy that no explanation of drumlins by iceberg action has yet been suggested. These hills indeed offer strong evidence against the sufficiency of that theory.

It is unnecessary here to enter on the evidence that places unstratified drift, with its scratched stones and large subangular bowlders, among the effects of land-ice action. Since it has been generally thus regarded, several suggestions of more detail have been made as to the origin of the peculiar form of drumlins. They have been considered the product of post-glacial erosion acting on a broad sheet of drift by W. Harte (Journ. Roy. Geol. Soc. Ireland, 1867, ii, 30) and Professor Shaler, (l. c.), but this explanation does not account for the remarkable parallelism between drumlins and striæ, and it assumes too great an amount of post-glacial erosion. Several authors, to be mentioned below, regard them as having attained their present form by local accumulation beneath the old ice-sheet, and this seems to me the most fitting suggestion. Prof. C. H. Hitchcock has thought that they may be due to the remodeling of old moraines under a second advance of the ice (Proc. Bost. Soc. Nat. Hist., 1876, xix, 66), and Prof. G. F. Wright has made a similar suggestion. Central New York gives this explanation its best support, for there the hills often stand closely side by side for many miles; but in New England, where the hills are scattered, with numerous and wide spaces between them occupied by insignificant deposits of till, the suggestion is not so

satisfactory. Professor J. D. Dana's description of Round Hill near New Haven (this Journal, 1883, xxvi, 357), would imply that it is a drumlin, although he calls it a kame; he suggests that it was formed by streams plunging down from the surface of the ice through a knot of profound crevasses, and "causing a local deposition of the stones and earth that were in the ice." But the absence of stratified sands and water-worn stones in the hill seem to negative this suggestion; and the occurrence elsewhere of numerous drumlins at high levels, as at Charlton, Mass., requires some other explanation.

The first clear reference to drumlins as directly dependent on glacial action for their form was made by M. H. Close (On the glaciation of the rocks near Dublin, Journ. Roy. Geol. Soc. Ireland, 1864, i, 3); they are here said to be parallel to the neighboring striæ, and hence like these dependent on the ice-sheet for their present attitude and form. The same conclusion is presented in the paper of 1866, above mentioned, when the name *drumlin* was first specially proposed for them. Still later, when describing the physical geography of the neighborhood of Dublin (id., v, 1877, 49), Close writes: "It is perfectly certain that it must have been the rock-scoring agent which produced the bowlder-clay ridges." Besides this, Kinahan and Close, in the pamphlet above named, stated their opinion that drumlins were formed in a way "similar to that by which a stream of water often makes longitudinal ridges of sand in its bed." This is to my mind the best suggestion yet given to account for them.

J. Geikie wrote as follows: "The remarkable linear direction of certain mounds of bowlder clay in some districts of the Lowlands, agreeing as this does with the general bearing of glacial markings of the same localities, induces us to believe that we have here, with certain modifications, the original contour of the till after the superincumbent ice-sheet had disappeared" (On denudation in Scotland since glacial times, Trans. Geol. Soc. Glasgow, 1867, iii, 61); but he believed that these forms may be also in part dependent on marine erosion. In the Great Ice Age (1877, 76), the same author briefly mentioned "the series of long smoothly-rounded banks or drums and sowbacks, which run parallel to the direction taken by the ice," and regarded them as very little modified from their glacial form. They are "produced by the varying direction and unequal pressure of the ice-sheet," and are "the glacial counterparts of those broad banks of silt and sand that form here and there upon the beds of rivers." Dr. L. Johnson says that he accepts Geikie's explanation and applies it to the New York ridges which were "formed underneath the glaciers by alternations of lateral pressure" (l. c. 1882); but this form

of statement does not commend itself so highly as the preceding.

In this country, Professor C. H. Hitchcock and Mr. Warren Upham, while engaged on the geological survey of New Hampshire, were the first to discover the parallelism between glacial motion and the axes of drumlins in 1875; they concluded that "the accumulation of these hills and slopes seems to have been by slow and long-continued addition of material to their surface, the mass remaining nearly stationary from the beginning of its deposition. Obviously this was the case with the lenticular slopes gathered behind the shelter of higher ledgy hills or upon their opposite sides" (Geol. N. H., 1878, iii, 308). A little later, Upham wrote: "Although we do not discover the cause of the peculiar distribution of these hills, it seems quite certain that they were accumulated and moulded in their lenticular form beneath the ice" (Proc. Boston Soc. Nat. Hist., 1879, xx, 223). Professor Chamberlin's observations led him to a similar conclusion: "The drift presents some peculiar tendencies to aggregation. . . . . A special tendency is observed over certain considerable areas lying not far from the Kettle moraine, to accumulate in mammillary or elliptical or elongated hills of smooth flowing outline" (Geol. Wisc., 1883, i, 283); and again, after repeating this opinion, it is suggested "that a deeply hidden boss of rock is usually and perhaps universally, the determining cause of these peculiar accumulations" (U. S. Geol. Survey, 3d Ann. Rep., 1883, 306).

In reviewing these explanations and the observations on which they are based, together with such evidence as my own studies have discovered, the conclusion that drumlins should be compared to sand banks in rivers appears the most satisfactory yet advanced. They seem to be masses of unstratified drift slowly and locally accumulated under the irregularly moving ice-sheet, where more material was brought than could be carried away. The evidence for the sub-glacial growth of drumlins may be summarized as follows: The scratched stones in the mass of bowlder-clay show a differential motion of its several parts as they were scraped and rubbed along from a generally northern source, and gradually accumulated where now found.* The compactness of the mass suggests an origin under heavy pressure. The attitude of the hills demonstrates a close dependence on the motion of the ice-sheet. The superposition of kames on their flanks proves that their present form was essentially completed when they were uncovered by the ice-sheet; and the small change of form in the kames shows that the drumlins also can have suffered very little from

* A paper by Mr. Hugh Miller, read at the recent Montreal meeting of the British Association, gave several admirable illustrations of this "fluxion structure in till."

post-glacial erosion;* the faint channeling of their smooth slopes by rain measures the small amount of denudation that they have suffered since they were made. It must therefore be concluded that they were finished closely as we now see them when the ice melted away, and hence that they were of sub-glacial construction.

The supposed manner of accumulation of drumlins may be briefly sketched. It is well-known that a stream of running water will at one point carry along silt and sand that must be dropped a little farther on where the current slackens; and the bank thus begun grows slowly in a form of least resistance, attaining a maximum size when its increase of volume has so far diminished the cross-section of the stream and consequently increased the velocity, that no more detritus can be dropped there; but even then, one end may be worn away while the other grows; the adjustment of velocity to channel is not permanent. The motion of a glacial sheet has been justly compared to that of a broad river. The comparison may be extended so as to liken the active head waters of a stream to the presumably fast-moving part of the ice-sheet near its source or center of dispersion, where the greatest erosion generally takes place. The delta of a river corresponds to the thinner and slower-moving marginal area of an ice-sheet, where drift brought from elsewhere is quietly and evenly deposited as in Minnesota, and where erosion is relatively weak.† A still further agreement is discovered in comparing the drumlins and sand-banks, found in the middle course of the molten and solid streams, as suggested by the several authors quoted above. In view of the irregularity of the surface on which the ice-sheet moved, and of the greater weakness of some rocks than others, we must suppose an irregular velocity in the motion of the ice and an unequal distribution of the rubbish beneath it. If the faster motion at one place cause an excess of erosion there, the slower motion at another place may bring about an excess of deposition. This difference of action is known to prevail between the central and marginal parts of glaciated areas; and the local accumulation of drumlins in an intermediate region gives a smaller example of these two parts played by the ice. If the causes of the irregular motion of the ice lie in the general form of the country, the location of faster and slower currents will be relatively permanent; the districts of faster currents would be found where the greatest volume of ice is allowed to pass, and some of the points of retardation

* This assumes a point on which there is now a tolerably general agreement: namely, that kames were formed close by the front of the melting and retreating ice.

† The recent history of this comparison is given in my paper on Glacial Erosion, Proc. Bost. Soc. Nat Hist., 1882, xxii, 33.

may be the seats of long continued drumlin growth. The drumlins thus begun will depend less on the immediately local form of the ground than on the topography of a more considerable district, and hence we need not suppose every drumlin to have begun its growth upon a knob of rock, although the beginning of many hills may have been thus determined. Once begun, the drumlins will go on increasing in size, as long as deposition exceeds erosion, always maintaining an arched form of least resistance, until a maximum size is reached, or until the ice melts away: and in their growth they will approach the form to which rough, rocky hills would be reduced by the reverse process of erosion, if time enough were allowed. Under unending glaciation, the whole surface must be rubbed down smooth.

I am well aware that it is venturesome to go so far as this in theory before all the facts are in. When more is known of the distribution of drumlins, the suggestions here given may have to be abandoned; but it is nevertheless impossible to resist theorizing, and perhaps the collection of facts, *pro* and *contra*, may be hastened by a little venture in speculation. It is very desirable that the regions occupied by drumlins should be more closely studied; when this is done, it may be possible to give in more definite terms the reasons for their choice of attitude, and additional chapters in their history may then be written.

Cambridge, Mass., October, 1884.

ART. XLIX.—*Geological Relations and Genesis of the Specular Iron-Ores of Santiago de Cuba;* by JAMES P. KIMBALL.

FOR a distance of at least some 20 miles east of the longitude of the bay of Santiago de Cuba, the Sierra Maestra, or coast-range, maintains a height of about 4240 feet, as barometrically measured by Mr. Emile Sarlabous, vice French Consul, at the point on its crest well known as Gran Piedra. On local maps of the Province of Santiago, this point is laid down as 5·69 miles from the coast of the Caribbean Sea, which is generally parallel to the crest of the range. The great outlier or escarpment of Gran Piedra, according to the same authority, presents the same lithological features as its lower foot-hills, namely—a coarsely crystalline syenyte of eruptive origin. Wherever this has come under my own observation, within the expanse of the lower foot-hills, it is penetrated by very numerous dykes of dioryte.

From the overflow of similar dykes, the upper immediate

flank of the Sierra Maestra and middle foot-hills are covered with a mantle of the same trappean rock. The maximum thickness of this mantle I estimate to be about 2000 feet, corresponding to an altitude of about 3800 feet.

The Sierra Maestra is the south (front or coastward) range, and last elevated, as well as the longest, of a series of successively elevated ranges, together forming the broad belt of mountain plateau, stretching nearly to the north coast, and running out to a point at Cape Maysi. West of the bay of Santiago, a lower range, of still subsequent elevation, forms the coast-range of the southern peninsula. This range is locally known as the Sierra de Cobre, although on general maps not distinguished from the Sierra Maestra.

Reference will presently be made to the more special lithological features of both ranges, within the limited scope of my observation. Occasion is here suggested to note as a significant fact in relation to the vulcanism of the Sierra Maestra, the family relation of the two types of eruptive rocks entering into the structure of at least the base and south flank of this range. The significance of this fact, in connection with others that will be noticed, appears to be that the overweighting of the syenyte mass along an inherent line of least resistance, corresponding to the margin of the sub-oceanic basin of the Caribbean Sea, has been followed first by depression, attended with re-melting of the base of the mass; and afterward by elevation. This elevation, it will be shown, has taken place by successive stages. The final, if not the concurrent, result of such oscillations of level has been to inject the molten magma in the form of dioryte through fissures incidental to elevation.

The diorytic mantle thins off toward the coast, in part by erosion, while the lower ranges of foot-hills are completely denuded of dioryte, if ever enveloped.

The immediate coast presents a remarkable development of coral rock, or coral limestone, in three terraces, of which the upper is about 350 feet above the sea. The second terrace is at an altitude of about 175 feet, and the present shore, a plateau of comparatively recent elevation, about 14 feet above tide. These terraces mark successive elevations of the Sierra Maestra range. These stages of elevation were in direct, but probably remote, succession with other elevations which I shall show to be indicated by traces of more ancient corallines (coral formations) about two miles still farther back from the present coast.

The last terrace, or that of the present shore, falls away vertically into deep water, soundings at the mouth of the Carpintero, 150 feet off shore, giving a depth of 165 feet. It retains to a remarkable degree the structure of solid reef, studded with

distinct forms of coral, and is strewn with fragments of coral, rounded by the waves, but in good preservation, and numbering a large variety of species.

The two older terraces retain little or nothing of corallum structure, but are thoroughly consolidated, indurated and crystalline. As an effect of the action of the waves in former periods, they still present mural escarpments seaward, with a talus at the base of each from weathering, and from clefts produced by the wedging effect of roots of trees.

The upper terrace reposes directly on the syenyte, and east of the Carpintero river (Juraguacito) forms the immediate coast. The base of the two lower terraces is concealed.

The bay of Santiago corresponds to an original recession of the coast, the eastern limit of which was the mouth of the river just mentioned. This recession was once filled out with coral formation. Subsequent to the final elevation of the Sierra Maestra, the coralline was eroded into the present land-locked form of the bay with the preservation of a wide margin of this calcareous rock. Both shores have been excavated from corallines, of which those already noticed are the more recent and easily distinguished. These present a bold front to the bay. The old Morra fortress is on the second and third terraces, numbered in inverse order of succession. Earlier corallines are less easily identified with what study I have been able to give to the region. The elevation of the Sierra de Cobre, the eastern end of which range faces the bay, seems to have resulted in the final elevation of the coralline area. The succeeding excavation of the bay has been effected with but little aid from existing streams, the present drainage of the mountain plateau of the Sierra Maestra and back ranges being to the east and west of it.

The bay of Guantanamo, 51 miles east and about three times the area of the bay of Santiago, possesses so many obvious points of resemblance to the latter, including littoral, topographical and hydrographical relations, as to suggest in both cases also similar geological relations. Mr. Sarlabous informs me that the margin of the larger bay, like that of its twin, is of coral-rock.

In the vicinity of Guantanamo Bay and thence eastward, the dioryte mantle appears from the sea to envelop the crest and the whole southern flank of the Sierra down to the coast. Place is given to this remote observation, confirmed as it is by Mr. Sarlabous.

The Juragua Hills, so-called, are the culmination of the middle ranges of foot-hills of the Sierra, about half way between the bays of Santiago and Guantanamo, or, more closely defined, between the mountain streams, the Carpintero (Juraguacito) and the Daiquri.

Along with a study of some very remarkable deposits of a specular ferric oxide, in course of development by the Juragua Iron Co. (Lim.), for consumption in Pennsylvania, these hills came under my observation in the months of June and July last.

As here distinguished, they consist of two parallel ranges of foot-hills distinct from the immediate south flank of the Sierra Maestra. The first or upper range reaches an elevation of about 2000 feet; the second or lower, of about 1100 feet.

Both ranges are the topographical result of the erosion of the south slope of the Sierra Maestra, within the compass of the dioryte mantle down to the underlying syenyte, and in the case of the lower range, well into the syenyte. The syenyte base of the upper range is occupied by the bed of the Carpintero, and that of the lower range by the Juragua and its east fork—the Benevolencia.

The lower contact of the dioryte mantle with the syenyte base of the Sierra (according, first, to unequal elevation and, second, to subsequent unequal erosion), follows a convoluted line. This contact corresponds, as I believe, to parts of a former coast line, as shown by traces of ancient corallines. These traces are as follows:

1. Isolated bodies of marble without stratification, but with marked prismatic cleavage. These invariably occupy the elevated parts of the contact.

2. Isolated bosses and other bodies of specular and amorphous ferric oxide, only partially dehydrated, which I take to be replacements of ancient corallines. These occupy the lower parts of the contact.

Referring both occurrences to their original relations to the coast, they seem to be relics of bodies of coral rock and of coral reef reposing on the syenyte. These masses became implicated in the igneous overflow, one or more than one, from the north. This is shown by the approximately east and west direction of the longer axes of them all. The upper ones, or those now occurring as marble, were probably of the nature of emerged coralline, while those occurring as ferric oxide, lower in position and farther to the south, were probably of the nature of coral-reef when involved in the eruptive flood. These are found directly back of the lower contact, while the bodies of marble, in a similar relation to the contact, appear to be farther back of it.

The thinning of the dioryte mantle toward the sea is thus seen to have been not altogether the result of its flow, slackening as may be supposed inversely to its mass, but to have been promoted by the extinguishing effect of the sea. The sea seems also to have brought the flow to a stop.

No traces of ancient coral reefs have been observed between

the contact, within the area of the still lower syenyte foot-hills, and the emerged corallines of the present coast margin. Yet such corallines may have once existed, and since disappeared by subaerial erosion.

Nor is proof afforded of any former extension of the dioryte mantle below or south of the contact. Diorytic dykes, nevertheless, in great number, penetrate the syenyte on every hand, their frequency becoming less toward the west, as distance increases from the culmination of the Juragua foot-hills. Beyond them, west of the Carpintero, but in line with the second range of foot-hills, or just back of the general course of the contact, the syenyte hills have been wholly denuded of dioryte, the hills themselves becoming gradually degraded toward the bay of Santiago, and exhibiting the extreme effects of weathering decay characteristic of highly crystalline feldspathic rocks in lower latitudes. Remnants of detritus, dioryte and hematite, upon the surface of these hills, attest the former extension of at least a thin development of the dioryte mantle. Unlike the lower syenyte hills of the Juragua group, these hills have not opposed to erosive agencies a great number of ribs or dykes of more enduring trappean rock.

In the absence of remnants of dioryte in place, the presence of specular ore-float in place is equally significant. For all recognized ore-bodies and marble-bodies are encompassed by dioryte, or by products of its weathering, though limited to its lower margin—the ancient littoral, and in part submarine, relations of which are argued as above.

The interesting question now arises whether the diorytic intrusions within what at the period of their vulcanism was a submarine syenitic area, below the level of the habitat of coral life—did not stop short of overflow. That such intrusions may have been limited in upward range by the submerged surface of the syenyte seems indeed probable on general grounds. Hence the erosion of the lower syenyte ranges of hills, three in number, of the Juragua group, may never have involved the disappearance of even a reduced thickness of the dioryte mantle, as compared with its medium (if not minimum) original development immediately back of the present contact. The proposition then is that the present syenyte contact, as far as indicated, was the actual lower limit of the dioryte mantle, as it is in fact at present. This I am inclined to believe.

The several terraces of recent coralline mark, as already indicated, successive, and in chronological order the later, uplifts of the Sierra, in vertical range not less than 500 feet. These, together with the series of corallines of the second line of foot-hills, as recognized by the bodies of hematite and marble, are proofs of a sum of uplifts of not less than 1300 feet.

Obscure traces upon the first range of foot-hills of still more ancient corallines, to which I shall again refer, point to a still more remote succession of uplifts whose vertical range—referred to the latest indicated level of coral formations, some 100 feet below the present shore—may be estimated as about 2300 feet. From the syenyte hills may have disappeared by subaerial erosion intervening corallines, between those of the present coast and the line of ancient, and now metamorphosed, corallines traced along the contact or southern margin of the dioryte mantle.

Dry beds of once powerful streams occupy deep defiles of the foot-hills, further attesting hydrographical changes of such a scope as may be believed to be commensurate to the degree of successive elevations of the Sierra. Such defiles are the arroyos Negro, Caridad, La Plata and Berraco. The dry and nearly filled up Laguna of Berraco, so-called, some fifteen miles east of Santiago Bay, and a few feet above tide, corresponds to a former indentation of the coast at the mouths of what appears to have once been two of the largest streams of the south slope of the coast range.

The syenyte of the lower foot-hills is weathered to a depth as far as yet penetrated by railway cuts. All fresh surfaces thus exposed exhibit its disintegration along divisional planes, with the result of an obliteration of its prismatic structure from jointing. The incomplete exfoliation of prismatic blocks between joints has resulted in the usual rounding of the undecomposed centers in the form of cores. At the surface, where freed from their interstitial products of decay, these appear as outlying bowlders. The weathering of the diorytic dykes which traverse the syenyte in directions of least resistance corresponding to its jointing, is indicated by the passage of their hornblende into epidote and chloritic residuums.

The dioryte also presents toward its lower margin marked phenomena of weathering decay or of metasomatic alteration. These will presently be described as subsidiary results of the process of epigenesis, or course of permutations, by which the calcareous material of implicated bodies of corallines has been replaced by ferric oxide.

The weathering of the upper parts of the dioryte mantle is less obvious. Yet, like all superficial masses of ancient (especially eruptive) basic rocks, it stands for a once more basic aggregate, from which protoxide bases have been largely eliminated in the form of sulphates and of alkaline bicarbonates. The epidotic character of much of the dioryte where least obviously weathered, is one of the proofs of the instability of the hornblende. Again, regarded as a feld-

spathic aggregate under conditions of extreme exposure to weathering action, all parts of the dioryte must be assumed to represent its effect, however unequal, and insusceptible of measurement without the partial preservation of the original type for comparison. This consideration is one of importance in the present case, because a large source of ferric oxide must be looked for to account for its accumulation, under favorable circumstances of drainage, in the form of the iron-ore bosses along the lower edge of the dioryte mantle, at its contact with the underlying syenyte.

Two series of circumstances have determined the *loci* of these iron-ore bosses, viz: (1) the *loci* on the ancient submarine slope of the syenyte on which coral-reef was reared, or on which coral sediments were piled up by the waves; and (2) subsequent favorable conditions for the supply of ferric oxide to replace lime carbonate as fast as it dissolved under the intermittent action of percolating acidulated waters and of alkaline bicarbonates.

1. Proof of the coralline parentage of the iron-ore bosses is the preservation in nearly all of them of fossil corals, or at least of casts of coral. Such casts are found toward the outer parts of ore-bodies, in what may be called their transition parts. These are in general siliceous from the segregation of silicates. While the lime carbonate of the casts referred to is replaced by ferric oxide, the cells of the corallum are filled out with segregated matter, more or less chloritic from secondary alteration.

The larger bosses, corresponding to coralline masses, exhibit a concentric structure characteristic of segregation by foliation or external deposition. The smaller ones, on the other hand, frequently present the peculiar warped surfaces characteristic of the coral rocks, and such as may be seen on every cliff or detached mass of coral rock in the terraces along the present coast.

The larger bosses may in a general way be described as lenticular bodies, any section of which is approximately elliptical. The smaller ore-bodies are of irregular shape and suggest a fragmentary relation to the larger ones, especially as they are always found near the larger, and invariably in such relations as would correspond to the superior surfaces of corallines referred to their original relations with their syenyte base.

The position of all the ore-bodies is on the inner or upper side of the syenyte contact, but laterally and terminally surrounded with altered diorytic rocks. This fact, together with the circumstance that their longer axes are approximately parallel to the crest of the Sierra as well as to the present coast, tends to show the parent corallines to have been involved in

the igneous flood down the Sierra slope from the overflow of innumerable dykes. The implication of the corallines in the flood of eruptive, was probably attended by elevation of the whole range, including the coast. Subsequent elevations have raised them higher, and further withdrawn the coast. Some of the ore-bodies are penetrated by courses of dioryte, now sometimes represented by chloritic kaolin. These I am disposed to refer to ramifications of the eruptive material in the act of overflow and upheaval.

2. The ore-bodies, whose general position is thus to be defined, occupy the thinning edge of the dioryte mantle. How far its reduced thickness is due to erosion, and how far to its original development, or to the circumstances of its flow, is partially indicated by the degree of erosion which the ore-bodies themselves have undergone. All that have been discovered have been more or less truncated by erosion.

The relation of the marginal region of the dioryte mantle to the great body of the same basic formation back of it, and to the underlying syenyte, and the preservation under conditions of energetic weathering of the syenite in hills in front, are circumstances readily recognized as favorable to metasomatic action along this margin. Underground as well as superficial drainage of both formations must have been directly toward this margin, especially before the present minor topography was sculptured. That the present topography has been wrought subsequent to the formation of the iron-ore masses is clear from the fact of their erosion by the streams, which now follow in part the same marginal region of decayed and decaying rocks.

Unequal elevation or unequal erosion, or probably a combination of both conditions, has served to introduce a series of conditions unfavorable in certain cases to the radical alteration of coralline masses. In such cases the coralline mass occurs in the form of white marble. In attitude and general relations both with the syenyte and dioryte such masses have only certain features in common with the ore-bosses. They have already been described as devoid of stratification, and as strongly characterized by a prismatic cleavage. They all occupy positions in the Juragua Hills toward the summits of the second range, at the base of which the ore-bodies are distributed. Under such circumstance all drainage both from the dioryte and the syenyte is and always has been away from them, and *pari passu* toward the iron-ore bodies. The encasing dioryte exhibits no marked phenomena of weathering. The argument for the limited degree of weathering sustained by this rock under such conditions, it will be noted, is by induction. Replacement of calcareous matter has gone on

only at the surface of such bodies as shown by the prevalence of float of ferric oxide remarkably pure, but evidently from small plates or segregations on their sides. Garnetiferous aggregates with considerable proportions of specular and magnetic oxides of iron are the most common products of metasomatism met with on the dioryte summits.

The marble ledges have, however, so many relations in common with the iron-ore bodies, the coralline parentage of which seems to me demonstrated, that they likewise must be referred to a similar primary origin. Their metamorphism or crystallization is due to igneous contact. Their preservation in the metamorphic state without metasomatic alteration, is explained as above by their obvious exclusion from the conditions which have governed the alteration into ferric oxide of other corallines, whose more favorable environment with reference to such an alteration, I now proceed to describe.

Toward the continuous base of the second range of hills the dioryte margin, just back of the contact, has passed into miscellaneous aggregates of a chloritic type. Such are the rocks which immediately encase the ore-bodies. They are soft, rotten and bleached. In color they are of various light shades of green. By further oxidation of ferrous silicates, this coloration has locally given way to darker complexions of red and brown, especially in such as exhibit a notable proportion of free silica, and a dense amorphous consistency. Aggregates of clear crystalline quartz in admixture with magnetic oxide of iron likewise occur, apparently as residual forms of the alteration under local circumstances of basic material originally containing a notable proportion of this oxide.

The syenyte conspicuously outcrops in contact with ore-bodies only in a single instance. This is the south ore-body of East Mine Hill. Here one side and both ends of the ore-boss abut upon the syenyte, which thus forms a *cul-de-sac*. The contact upon the exposed side is occupied by two courses of rotten, aluminous and bleached chlorite in a kaolinized state. These are succeeded by a plate of amorphous siliceous and highly ferriferous material, 3 feet in thickness, within the compass of the ore-body and forming its outer wall. Irregular courses of chloritic and distinctly aluminous material correspond to outer shell-like divisions of the ore-body, due, as I suppose, to the exfoliation of siliceous (insoluble) matter in the process of molecular rearrangement of the mass in the process of segregation and concentration of ferric oxide, attending its replacement of lime carbonate. A part of the siliceous matter thus exfoliated probably represents detrital contents of coralline masses; another part the alteration *in situ* of ramifications or tongues of diorytic eruptive material intruded into frac-

tures of the original coralline mass when overwhelmed and lifted.

Courses of chloritic material of the above description encase the lower ends, at least, of all the ore-bosses wherever terminal parts have been uncovered by excavations. These conform to the general lenticular outline already referred to, and hence are to be referred, as above, to exfoliated insoluble residuums. They are similar in type to the intrusions of siliceous material within the compass of the ore-bodies. The decomposition of dyke-like ramifications *in situ* is seen to result in a product indistinguishable from the residuums instanced from diorytic detritus in the parent coralline. This may be supposed to follow from the qualitative identity of such detritus with the dioryte from which it was mainly derived.

The terminal parts of only the lower and more accessible ends of the ore-bodies have thus far been exposed by excavations at the base of the hills, and just back of the contact, where, in the course of its convolutions, this conforms to the southerly course of streams. The longer axes of the ore-bodies are therefore transverse to such parts of the beds of streams as have been eroded along the contact. Only where assuming a longitudinal direction has the contact, for obvious reasons, presented to erosion the line of least resistance.

The chloritic courses immediately encasing the ore-bosses, and which have been described as exfoliated residuums, alternate with divisions of siliceous ferric oxide. Incomplete quaquaversal or rounded dips are thus observed at the lower terminal parts of ore-bodies. The concentric structure, of which they are the outer manifestation, prevails as far as can be seen within the interior of the less eroded ore-bosses where penetrated by drifts. Hence a divisional structure resembling that of an onion, and easily mistaken for bedding. The shell-like divisions, elsewhere described as transition parts of ore-bosses, give way inside to massive ore divisionally arranged as above instanced. The conditions of the central and nether parts of the larger ore-bosses have not yet been brought to light. The center of the south ore-boss of East Mine Hill appears to be not far away from its eroded surface. The ore is there presented in massive form and of extraordinary purity.

The larger ore-bodies present all the numerous physical types of specular oxide, besides a variety of phases from unequal distribution of pyrite and of magnetic and manganic oxides, and from an unequal degree of hydration. Earthy admixtures are of a chloritic and epidotic type, and thus essentially basic, differing in this respect from Huronian speculars whose earthy tendency is decidedly acid from segregations of quartz or from intercalations of jasper. As returned by numerous average

proximate analyses from commercial samplings, exclusive of my own, moisture, in part hygroscopic, is constantly present in percentages of 0·24 to 0·81; silica and insoluble 5 to 10½; phosphorus 0·009 to 0·065; sulphur 0·045 to 0·248; and iron 61 to 68½.

It is needless here to follow out what may be termed the circular processes of the epigenesis of ferric oxide from basic rocks through the mediation of meteoric waters charged with organic, sulphuric and carbonic acids, and of its preservation under favorable conditions. The replacement of soluble lime carbonate by comparatively insoluble ferric hydrate in the act of peroxidation from ferrous carbonate and from ferrous sulphate, and its concentration under favorable conditions by segregation or as a sediment as the case may be, are common and well known phenomena.

The Clinton so-called fossil-ores of the Upper Silurian areas of the United States afford a familiar example of the replacement of limestone by ferric oxide. The Archean specular ores of the James River of Virginia are an example of the segregation of ferric oxide from metamorphic schists *in situ*. Eruptive porphyries of Leadville, Colorado, have given origin to similar segregations. The gossans of almost every mineral vein further illustrate the familiar phenomena of epigenesis of ferric oxide. The Cuban iron-ores, above described, differ from the Archean schistose deposits of Michigan and Wisconsin, and from the bedded parts of the deposits of Pilot Knob and Iron Mountain of Missouri, in the following particulars: (1) They have had their immediate source in eruptive rocks rich in protoxide bases instead of metamorphic rocks comparatively poor in proto-silicates. (2) Their ferric oxide has been concentrated without ever reaching hydrographical channels of drainage, and therefore preserved almost *in situ* without the mediation of basins. (3) The basic character of their siliceous impurities, occurring as residuums, characterizes them still further from both classes of Archean ores, especially from the schistose, whose accessory admixtures are not only acid but of the nature of segregations, intercalations and mechanical sediments. These in point of sizable development and, cursorily regarded, in general lithological appearance are, however, their nearest familiar analogue.

Besides the iron-ore bodies above described as *replacements*, another class of deposits of ferric oxide remains to be described. These may be distinguished as *concentrations*. These are partially altered diorytic masses characterized by a notable but unequal concentration of ferric oxide *in situ*. The outcropping portions of such masses are often no less rich in specular oxide than the ferric replacements of coralline,

from which, however, they are readily distinguished by their superior hardness and density, and by their sharp metallic sound when struck with a hammer, as well as by the circumstances of their metasomatic association with unaltered or incompletely altered dioryte.

What has determined the localization of such deposits within the dioryte mantle has not been made clear. Certain indicated circumstances rather than well ascertained facts, seem to bear upon this question. (1) The location of such deposits, as far as recognized, is near the contact, but not uniformly immediately back of it, as in the case of the ore-bodies of coralline parentage. Some relation between the two classes of deposits may be suspected from the fact that an occurrence of this kind is recognized alongside, and probably in contact with, the developed lenticular north ore-body of West Mine Hill; while alongside a similar trappean concentration in Dry Arroyo, further up the same hill, the presence of lenticular ore-bodies of the nature of replacements is indicated.

Ferriferous parts of the dioryte referred to are usually beneath the detritus, and may be considered as representing a state of weathering intermediate between the normal dioryte and its bleached and obviously weathered products. Such occurrences are a conspicuous feature of the first range of foot-hills. On the Yuca Mine location, what appears to be garnetiferous casts of corallum have been found in juxtaposition with an ore-deposit of this description. This is the only relic, if such it be, of the former existence of corallines discovered by me so far back as this range of foot hills.

The question therefore arises whether obscure and in some places obliterated corallines may not under such circumstances have given way to available replacements of which ferric oxide was but a minor part, and have determined the *loci* of such metasomatic activity or chemical permutations as to have resulted in the exchange of acids and bases in the basic and pyritiferous eruptive, followed by concentration of ferric oxide. The peroxidation of ferrous oxide *in situ* is easily conceived to have been a result from the tardy circulation, in so dense an aggregate, of chalybeate, or of solutions of the vitriolized products of iron and copper pyrites, especially under the further condition of an adjoining body of limestone. Calcic carbonate has also been at hand from decomposing silicates.

As a corroboration of the general induction, such occurrences may be held to attest an originally more basic constitution of the dioryte, and especially a once larger proportion of ferrous oxide, and accordingly of proto-silicates. Minor exhibitions of the same general class, but clearly without the mediation of limestone, are outcropping surfaces of diorytic

dykes, the identity of some of which seems to have been preserved within the compass of their general overflow, or, as above distinguished, the dioryte mantle. The concentration of ferric and magnetic oxides upon such surfaces, presents outliers popularly regarded as outcrops of ore-bodies of great richness. A few blasts are generally sufficient to prove their superficial character. Cupreous stains of green carbonate from the epigenesis of a sulphide of copper, are found within the ore-bosses of coralline origin as well as in the interior of ferriferous parts of the dioryte.

The copper deposits of the Sierra de Cobre west of the Bay of Santiago, exhibit to a remarkable degree still active metasomatism of the diorytic porphyry in which they occur. Not only is the overflow of mine-water from the abandoned mines a present source of cement-copper, but exfoliations more or less cupreous are observed on all weathered surfaces of wall-rock left standing by the old English companies. Even individual fragments of dioryte detritus in the old burrows have become completely coated with exfoliated mineral matter. Ferric, as well as miscellaneous cupreous products thus occur, along with a variety of silicates and other insoluble compounds. Even the old slags show zeolitic and other drusy segregations. Secular phenomena of this kind may be considered as in part an effect of the humidity and high mean average temperature of the climate.

Under the same favorable climatic conditions secular weathering, or metasomatism of eruptive basic rocks, has gone on to a remarkable degree throughout the whole region above briefly described. Permutations of this kind tend to produce from the eruptive, now represented by dioryte, a series of rocks resembling in lithological character metamorphic chloritic, garnetiferous and ferriferous schists. The basic character of the prevailing admixtures of the latter, occurring in association with the ferric replacements of corallines, is their most obvious lithological point of difference from the prevailing type of Huronian specular schists, which as above remarked are essentially acid. Thus, they more closely resemble certain Laurentian magnetite-schists whose earthy admixtures are generally basic. Yet quarztiferous aggregates are not wanting among the great variety of ferriferous admixtures here referred to.

The ferro-garnetiferous aggregates are characterized by a subcrystalline groundmass of wine-colored garnet, probably magnesian, with druses of magnetite, and a minor proportion of the same oxide irregularly scattered throughout the mass. Narrow ledges of this rare material in West Mine Hill are remarkably continuous. Their occurrence is under such circumstances in general as to indicate their relation to the single series of dykes,

the individuality of some of which has been preserved within the compass of their collective overflow. So considered, they may be taken as a special metasomatic transformation, governed by obscure local conditions, of certain dykes belonging to the same series as chloritic, epidotic and ferriferous outcrops, as well as distinct diorytic courses, readily differentiated as dykes, within the more porphyritic mantle. The latter, it is conceived, represent, under limited dynamical conditions (whence their extreme density of grain amounting in places to almost aphanitic aggregation), the least advanced state of weathering of the original eruptive. Among the numerous pseudomorphic relations of garnets, may be recognized some corresponding in kind to the metasomatic relations which may be supposed to exist between massive garnet rock and basic eruptives, along with the altered alumino-magnesian silicates whose transformation has also been wholly or in part by loss of certain ingredients.

Labradorite-dioryte more or less chloritic and of metamorphic origin, as well as metamorphic representatives of a long series of intrusive species of rocks, have been described by Prof. Dana and the late Mr. Hawes. "The fact," as remarked by Mr. Hawes, "that metamorphic action can produce rocks exactly like the igneous in external aspect and chemical constituents is of great interest in the study of rocks."* It seems almost certain that ancient eruptives afford few if any standards for such comparison where permutations of the nature of metasomatism have not led to their resemblance to related metamorphics. This may be assumed especially in the case of chloritic and epidotic rocks.

The chloritic products from alteration of the Sierra Maestra epidotic dioryte closely resemble, as above remarked, metamorphic occurrences of chloritic schists. Such resemblances tend to indicate, indeed, a middle ground where meet products lithologically identical, proceeding on the one hand from basic eruptive rocks by metasomatism, and on the other hand from sedimentary rocks by metamorphism. Resemblance between essentially chloritic aggregates of both types hardly needs the confirmation of analyses.

The dioryte of the Sierra Maestra, though not without traces of orthoclase, is essentially plagioclastic. The syenyte is mainly orthoclastic with occasional crystals of triclinic feldspars. The basalts indicated by Ansted in 1856 would now be classed as dioryte.†

* This Journal, 1876, xi, 126. † Proc. Geol. Soc., xii, 144.

Lehigh University, Bethlehem, Pa., Oct. 10, 1884.

ART. L.—*A New Tantalite Locality;* by CHARLES A. SCHAEFFER, Cornell University.

AMONG some specimens of the minerals found at the Etta tin mine, Dakotah, and recently come into my possession, a number of pieces, which on first glance were supposed to be cassiterite, proved to be tantalite. Professor Blake in speaking of the ore from the same locality (this Journal, III, xxvi, 235) says, "a few crystals of a black mineral believed to be wolframite have been seen in the mixtures of spodumene and feldspar." A careful search of all the specimens received has resulted in finding no wolframite but a considerable quantity of the tantalite. The probability is that tantalite is the mineral to which Professor Blake referred. An analysis of the tantalite gave the following results.

Tantalic oxide	79·01
Stannic oxide	0·39
Ferrous oxide	8·33
Manganous oxide	12·13
	99·86

This shows a much simpler composition than either the tantalite found in small quantities in Alabama and analyzed by the late J. Lawrence Smith, which contained tungstic acid and oxides of zinc and copper, or the mineral from North Carolina, analyzed by Dr. Koenig, which contained a considerable quantity of magnesia.*

The portion analyzed consisted of fragments, taken from a mass about the size of an egg, and was entirely free from any peroxidized iron. Its sp. gr. was 7·72. The determination of the sp. gr. of three small specimens, taken from a sample of stream tin, which were water-worn and externally brown, gave the following results: 6·12, 6·545 and 6·777.

Accompanying the ore, in addition to the minerals enumerated by Professor Blake, were found scorodite, containing kernels of leucopyrite, and olivenite. Qualitative examination showed the two former to be entirely free from sulphur.

* Watt's Dict., vol. iii, 3d Supl., Pt. 2, p. 1889.

ART. LI.—*Note on Paleozoic Rocks of Central Texas;* by CHAS. D. WALCOTT, of the United States Geological Survey.

THE writer had the opportunity the past season to make a hurried reconnoissance of a portion of the Paleozoic area of Central Texas: the chief object in view being the study of the Cambrian section and the collecting of fossils from the Texas Potsdam horizon.

At all localities where the base of the Potsdam was observed, it rests, *unconformably*, on a great formation that is stratigraphically the equivalent of Powell's Grand Cañon series (Grand Cañon and Chuar groups).* In the Grand Cañon of the Colorado the latter are overlaid by the Tonto group, a series of rocks, in both lithologic and paleontologic characters, singularly like the Texas Potsdam group.

For this series of Pre-Potsdam strata the local name of Llano group is proposed from the best exposures of the group occurring in the county of Llano. Outcrops also occur in Burnet, Mason, San Saba, Blanco and Gillespie counties.

The finest exposure seen by the writer, in direct contact with the base of the Texas Potsdam group, is along the western base of Packsaddle mountain, in Llano county. Here the massive reddish colored sandstones of the Potsdam strike north and south with a slight dip to the eastward, and rest on alternating beds of shale, sandy shales, sandstone, limestone and schists that strike east and west, dipping south 15° to 40°. The strata exhibit but little evidence of metamorphism, being indurated but little more than the beds of the overlying Potsdam and Carboniferous. The section shows the Llano and Potsdam groups unaffected by changes subsequent to the consolidation of the Potsdam sediments.

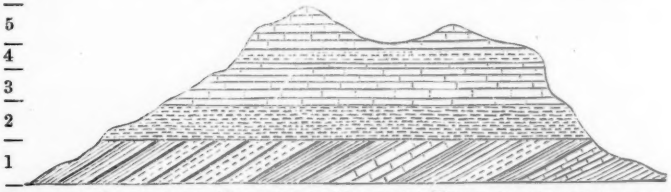
Across the valley of Honey creek, four miles west of Packsaddle mountain, the strata of the Llano group have been more metamorphosed, plicated, and broken by intrusive dykes of granite. This is along the eastern base of a ridge of Potsdam Silurian and Carboniferous rocks that strike eastward with a dip that increases from 10° at the north end of the ridge to 40° at the south end. The movement producing this position, as compared with the Potsdam beds of Packsaddle mountain, appears to have been at the close of the Paleozoic, and to have caused, in part, the metamorphism of the strata of the Llano group, but was not accompanied by the intrusive rocks, as they are Pre-Potsdam—in part cotemporary with the deposition of the sediments of the Llano group, but more largely the result of extrusions of granite at or near the close of the

* This Journal, vol. xxvi, p. 437, 1883.

erosion of the Llano group and before the deposition of the Potsdam. It is to this age that the great masses of granite observed in western Burnet and all through Llano county belong. At the crossing of the Llano river, on the road from Burnet to Honey Creek Cove, fragments of the shales and sandstones of the Llano group may be seen imbedded in the granite, and on Morgan's creek, Burnet Co., the Potsdam rests directly on the granite.*

The thickness of the Llano group was not determined owing to lack of time to study it in detail. In Honey Creek valley, from two to three thousand feet of shales, sandstone and limestones were observed, and northwest of the town of Llano a great mass of reddish sandstone occurs.

On Roessler's map of Llano county,† all of the Llano group is referred to as "granitic, metamorphic and igneous," and has been considered as Archean. The writer did not observe any rocks of undoubted Archean age. No fossils were found in the Llano group, but, from its lithologic character and position in relation to the overlying Potsdam, I refer the group to the Paleozoic, and correlate it with the Grand Cañon groups which are of Paleozoic age and referred to the Lower Cambrian.‡



SECTION OF PACKSADDLE MOUNTAIN SHOWING THE UNCONFORMITY BETWEEN THE POTSDAM AND LLANO GROUPS.

1 = Llano group.		
2 = Massive Potsdam sandstone	205·	feet.
3 = Potsdam limestone	310·	
4 = Potsdam sandstone	30·	
5 = Potsdam sandstone	60·	
	605·	

POTSDAM.

The Potsdam horizon has been well described by Shumard.§ The writer collected several thousand specimens of fossils from

* It may be that further and more complete observations will prove all the granite to have been intrusive in the Llano Group prior to its erosion, but from the evidence, as seen by the writer, it is difficult to explain its occurrence except as above.

† Map of Llano county, Texas, A. R. Roessler, New York, 1875.

‡ Since the paper on the Pre-Carboniferous strata of the Grand Cañon was published (this Journal, vol. xxvi, p. 487), a fragment of a trilobite, probably of the genus Ptychoparia, has been detected in a bit of shale from the Chuar group.

§ This Journal, II, vol. xxxii, p. 213, 1861.

its sandstones and limestones in order to study the fauna more thoroughly and to illustrate Dr. Shumard's species. A section was also found on the west side of Honey Creek valley that shows the contact with the Llano group below, the passage into the Silurian above, and the thickness of the Silurian up to the base of the Carboniferous.

The section gives 245 feet of sandstone and 625 feet of limestone; all marked by the presence of an abundant Upper Cambrian (Potsdam) fauna; Lingulepis, Orthis, Agnostus, Ptychoparia and Dicellocephalus.

The upper beds of the Potsdam become compact, hard and have a little included cherty matter. The fauna terminates here as far as observed and it is not until over one thousand feet of limestone are passed through, that recognized fossils again occur. The fauna is then of the type of that of the Calciferous group. A number of fine specimens were collected of the genera Ophileta, Straparollus, Murchisonia, Orthoceras and Bathyurus.

A massive bed of limestone, sixty feet thick, rests on the Silurian beds, 1145 feet above the upper beds, carrying Potsdam fossils, and directly above it limestones of a slightly different character carry common Carboniferous fossils, viz: *Productus semireticulatus*, *P. Nebrascensis*, *P. Prattenianus*, *Streptorhynchus crenistria* and *Bellerophon* sp.?

A vertical fault, parallel with the strike of the strata, breaks the continuity of the section about 300 feet above the summit of the Silurian, and the study of the Carboniferous was not taken up in detail.

On the Colorado river, in San Saba county, a collection of cephalopod shells, of the genera Goniatites, Nautilus and Orthoceras, was obtained from the Carboniferous, and on the San Saba river a quantity of corals were collected.

The results obtained are: additional data on the Potsdam section and fauna; the Silurian section and fauna; Carboniferous fauna; the geologic relations of what has long been known as an Archean area and which is now referred to the Cambrian, and the determination of the age of the granite of Burnet county.

ART. LII.—*On the Sufficiency of Terrestrial Rotation for the Deflection of Streams;* by A. C. BAINES.

IN a paper on this subject in the June number of this Journal Mr. G. K. Gilbert has investigated the combined effect of the earth's rotation and the centrifugal force in causing a difference in the velocity at the right and the left banks of rivers, and has shown that where a river flows in a curve the line of maximum velocity is shifted toward the right bank by the combined action of the deflecting force due to the earth's rotation and the centrifugal force developed in moving along a curve. Mr. Gilbert comes to the conclusion that the earth's rotation is effective in causing the erosion of the right bank, only in connection with and as an adjunct to the centrifugal force—or that the earth's rotation has no effect in shifting the courses of straight streams.

No other conclusion seems possible when only the extremely small difference in the velocity at the right and left banks due to the earth's rotation is taken into account for the small excess of erosive power at the right bank would, as has been remarked by others, be entirely neutralized if the right were only a very little higher than the left bank.

I shall examine the effect of the difference of the surface and bottom velocities of streams, in connection with the earth's rotation, and shall try to show that this difference accounts for the erosion of the right bank and deposition at the left in straight channels. In what follows, the northern hemisphere is always referred to.

If the whole water at any cross-section of a stream moved with the same velocity, every particle would be acted on by gravitation, and by the deflecting force. These forces would be equal for every particle and their resultant would be inclined to the vertical at an angle whose tangent is the deflecting force divided by the force of gravitation, and a line drawn on the surface of the stream from right to left would be inclined to the horizontal at an equal angle, and no motion of the particles of water among themselves would be caused by the earth's rotation.

The case is different in actual streams, where the velocity at the surface is greater than at the bottom. In order to simplify the investigation when this difference is considered, suppose the channel to be straight, of uniform cross-section, and the bottom flat. Also let the retarding effect of friction at the sides be omitted, taking into account only that caused by friction at the bottom.

Let v be the velocity of any particle in the stream; let v_1 be the velocity of any particle at the surface; let v_2 be the velocity

of any particle at the bottom; let F be the deflecting force due to the earth's rotation on a particle whose velocity is v. Then $F=2nv \sin \lambda$ where n is the angular velocity of the earth, and λ the latitude. Let F_1 be the deflecting force on a particle at the surface; let F_2 be the deflecting force on a particle at the bottom; θ the angle of inclination to the horizon of a line drawn on the surface across the stream; w the weight of an unit of volume of water.

As in the stream now under consideration the surface velocity is greatest, θ will evidently be less than if the whole stream moved together with the velocity v_1, i. e., less than $\tan^{-1} \frac{F_1}{g}$. Also, θ will be greater than $\tan^{-1} \frac{F_2}{g}$.

It seems probable that θ will not differ much from the angle whose tan = the sum of the deflecting forces acting on a thin slice between two cross-sections near together divided by the weight of the slice.

It is not necessary that θ should be accurately determined, as the following reasoning requires only that its tangent should be between the two values above mentioned. Suppose, therefore, $\theta = \tan^{-1} \frac{2nv_0 \sin \lambda}{g}$, v_0 being some velocity between v_1 and v_2, probably not differing much from the mean velocity of the stream.

Suppose a cube of water in any part of the stream whose sides are x, y, z; x being measured along the stream, y across it, both horizontally, and z vertically. The surface of the water stands higher above the right face of the cube than above the left, by the length $\tan \theta\, y$. Therefore the hydrostatic pressure is greater on the right face by the quantity $w \tan \theta\, xyz$, or $\tan \theta\, W$, W being the weight of the cube. Expressing $\tan \theta$ in terms of the deflecting force and gravitation, the excess of hydrostatic pressure on the right face $= \frac{2nv_0 \sin \lambda\, W}{g}$. This pressure tends to move the cube from right to left across the stream in opposition to the deflecting force, and the resultant of the two forces is their difference, or $\frac{2n \sin \lambda\, W}{g} (v_0 - v)$, v being the velocity of the cube down the stream.

If v_0 is greater than v, as is the case if the cube is at the bottom, the resultant force is from right to left, and the water near the bottom will be urged across the stream in that direction. If v_0 is less than v, as is the case near the surface, the water must be urged from left to right.

In actual streams where the friction at the sides diminishes

the velocity and the angle θ varies at every point along a line drawn across the stream. Suppose the water to be divided into a number of small vertical columns, then the above reasoning applies to each column and the forces acting on each will be similar in direction though differing in intensity, and there will be a transverse motion of the water, the surface and bottom layers moving in opposite directions, and necessarily a downward motion at the right bank, and an upward motion at the left. The resultant transverse force is greatest at the bottom and surface, and diminishes to nothing at the layer whose velocity is v_0.

The transverse motion must be extremely slow, and will be combined with that down the stream, so that the actual motion will be inclined at a very small angle to the direction of the channel. It is clear that a very slow motion of the bottom layer from right to left must cause transfer to the left side of the river bed of sand, gravel and mud, moved along by the current. The effect of this is to make the left shore more shelving, and the right steeper, and to place the deepest part of the stream near the right bank, thereby increasing the velocity, and consequently the erosion. The left shore being more shelving, will be more favorable to the resting of sediment during floods. The deposition at the left bank explains how it is that a stream can cut away a high terrace on one side, the low-lying shore on the other being added to instead of being removed.

The expression for the resultant transverse force on a particle at the bottom, $\frac{2n \sin \lambda W (v_0 - v)}{g}$, v being the velocity at the bottom, may be used to give a rough approximation to the force urging the bottom layer towards the left bank. Suppose $(v_0 - v)$ = two feet per second, the latitude 45°. The expression becomes

$$\frac{W \times 2 \times 0{\cdot}0000729 \times 0{\cdot}707 \times 2}{32{\cdot}2} = \frac{W}{156230} \text{ nearly,}$$

which is equivalent to a fall of a little less than half an inch in a mile, enough to cause a perceptible movement *down* a river channel of moderate size, and perhaps enough to cause a transverse motion above described, which would be perceptible by its effect, accumulating as it does for ages, in the same direction.

In bends, as James Thomson has shown, there is a flow of the surface water toward the convex side of the stream, and an underflow in the opposite direction. It is clear, therefore, that the deflecting and centrifugal forces must be added or subtracted, as the convex side is on the right or left side of the stream.

Christchurch, New Zealand.

ART. LIII.—*Chemical Affinity;** by JOHN W. LANGLEY, Ann Arbor, Michigan.

[Concluded from page 373.]

III. THE EXISTING PROBLEM.

The history of the various modifications and additions which have been made to the primitive conception of the nature of affinity, when briefly summarized, appears to be this.

Hippocrates held that union is caused by a kinship, either secret or apparent, between different substances. Boerhaave believed affinity to be a *force* which unites unlike substances. Bergman and Geoffrey taught that union is caused by a selective attraction, and therefore they called it "elective affinity." Wenzel and his successors showed that affinity is definite in action and amount. It has limits, or proceeds *per saltum*. Berthollet contended that affinity is not definite; he proves that it is often controlled by the nature and the masses of the reacting bodies. Dalton, Berzelius, Wollaston and others, held on the contrary this force to be definite and to act *per saltum*. It is a power which emanates from the atom. Davy, Ampère and Berzelius believed affinity to be a consequence of electrical action. Avogadro, in one way, and Brodie in another, show us affinity exerted by molecules as well as atoms; it is a force which binds together not only particles of the same substance but also of heterogeneous substances.

From the fact of the actual existence of radicals and from the phenomena of substitution was developed the notion of position, and that therefore affinity varied with the structure of the body as well as with its composition. The difference between the number of atoms which are equal to hydrogen in replacing power has led to the doctrine of valence, which, if it has any influence on theories of affinity, shows that this property of matter has two distinct concepts; one its power of attracting a *number* of atoms, the other its power of doing work or evolving energy. These two attributes seem to be in no way related to each other.

Mendelejeff and Lothar Meyer have shown by the facts which are grouped under the title "periodic law" that the properties of elements seem to be repeating functions of the atomic weight. Hence affinity is connected in some way with that same property which is also shown by the differential action of gravitation on the absolute chemical unit of matter. Finally, Williamson, Kekulé and Michaelis have suggested that combination is brought about and maintained by incessant

* Address before Section "C" of the American Association for the Advancement of Science, Philadelphia, 1884.

atomic interchange; hence that affinity is fundamentally due to some form of vibration.

We see that the primitive notions of affinity have undergone extensive modifications. The idea which seemed so simple and natural a one to Hippocrates has grown successively more complex and less sharply defined; for while it presented itself to him as a single cause depending on kinship or occult resemblance we now find it branching out into a many stemmed structure inextricably entangled with other physical forces and having its roots deep down in the regions of the mysterious and the unknown. When we look for an advance in precision of ideas, for a logical development of a satisfactory theory, or for generalizations which shall help us better to classify chemical phenomena in terms of force and energy, we are compelled to admit that the years have not brought the theory of affinity to a state of active growth; rather it is like that strange counterpart of a living tree, the branching coral, whose many busy workers do indeed each for themselves add their mites to the accretions of past generations, but who have failed with all their toil to infuse that mysterious principle which would make of their labors a living organism ruled by an internal law of growth.

Affinity, under its own name, is no longer presented in recent manuals. Chemists have more and more turned their attention to details, to accumulating methods of analysis and synthesis, to questions of the constitution of salts, to discussions about graphic and structural formulæ, and to hypotheses about the number and arrangement of atoms in a molecule; but they have not, until quite recently, made systematic attempts to measure the energies involved in reactions. Why?

I believe the answer can be found mainly in two reasons. First, the word affinity is in bad odor; it dates back to the time when men mistook wild guesses for ascertained facts; when they knew not the distinction between physics and metaphysics, and when a plausible but flexible *occuli* cause was a more welcome guest to a philosopher's brain than a stiff hard-headed fact. We see how enormously complicated the phenomena of chemical action have become and we have lost all faith in hypotheses which can be evolved by the mere force of metaphysical introspection. Therefore we are afraid to retain a name which once belonged to an idea now long buried in the limbo where so much scholastic rubbish has been consigned, and hence all the facts belonging to affinity are given under separate heads and thus they lose the great advantage of being bound together under one title.

Secondly, there is a more important reason arising from what has hitherto been the traditional scope of our science.

Natural Philosophy early sought the aid of Mathematics, and so laid the foundation for the comprehensive physics of to-day. Astronomy has always dealt with numbers, and hence stands as the best type of an exact science. Mechanics, in its analytical form, is little else than a material embodiment of algebra and geometry. Chemistry alone of the physical sciences has offered no foothold to mathematics, and yet all her transformations are governed by the numbers which we call atomic weights What is it which causes chemistry, so preëminently the analytic science of material things, to be the only one of her group which does not invite the aid of mathematics, the great analytic science of immaterial things? It is because three fundamental conceptions underlie physics while only two serve the needs of the chemist.

If I may borrow a term so much used just now by geometers, I would say that physics is a science of three dimensions, while chemistry is a science of two dimensions. In the first, nearly every transformation is followed by its equation of energy and this involves the concepts space, mass, time; while in the second, an ordinary chemical equation gives us the changes of matter in terms of space and mass only, that is to say, in units of atomic weights and atomic volume. Think for a moment what physics would be to-day without those grand generalizations, Newton's theory of gravitation, Young's undulatory theory of light, the dynamic theory of heat, the kinetic theory of gases, the conservation of energy, and Ohm's law in electricity. Every one of these, except the last, is a dynamic hypothesis and involves velocity, that is time, as one of its essential parts. In comparison with the above, all ordinary chemical work may be termed the registration of successive static states of matter. The analyst pulls to pieces, the synthetic chemist builds up; each records his work as so many atoms transferred from one condition to another, and he is satisfied to exhibit the body produced quietly resting in the bottom of a beaker, motionless, *static.* The electrolytic cell tells us the stress of chemism for specified conditions as electromotive force; the splendid work done in thermo-chemistry enables us to know the whole energy involved when A unites with B or when A B goes through any transformation however intricate, but it does not inform us of the dynamical equation which accompanies them, and which should account for the interval between the static states.

Whenever we look outside of chemistry we find the lines of the great theories along which progress is making are those of dynamic hypothesis; if we go to our biological brethren we see them too moving with the current; the geologist studies upheavals, denudation, rate of subsidence, glacial action and all

kinds of changes in reference to their velocity; the physiologist is actively registering the time element in vital phenomena through the rate of nervous transmission, the rate of muscular contraction, the duration of optical and auditory impressions et cetera; and we cannot ignore the fact that all the great living theories of the present, contain the time element as an essential part. Now may it not be that the reason why chemistry has evolved no great dynamical theory, that the word affinity has disappeared from our books, and that we go on accumulating facts in all directions but one, and fail to draw any large generalization which shall include them all, is just because we have made so little use of the fundamental concept, time. To expect to draw a theory of chemical phenomena from the study of electrical decompositions and of thermo-chemical data, or from even millions of the customary static chemical equations would be like hoping to learn the nature of gravitation by laboriously weighing every moving object on the earth's surface and recording the foot-pounds of energy given out when it fell. The simplest quantitative measure of gravity, is, as every one knows, to determine it as the acceleration of a velocity; when we know the value of g we are forever relieved in the problem of falling bodies from the necessity of weighing heterogeneous objects at the earth's surface, for they will all experience the same acceleration; may there not be something like this grand simplification to be discovered for chemical changes also?

The study of the speed of reactions has but just begun; it is a line of work surrounded with unusual difficulties, but I confidently believe it contains a rich store of promise; all other means for measuring the energies of chemism seem to have been tried except this; is it not therefore an encouraging fact that to us, the chemists of the nineteenth century, is left for exploration the great fruitful field of the true dynamics of the atom, the discovery of a time rate for the attractions due to affinity.

Art. LIV.—*Peculiar Modes of Occurrence of Gold in Brazil;* by Orville A. Derby.

1. Natural deposition of Gold from solution.

The following facts are believed to justify the heading of this paragraph. A specimen (Mus. No. 84) in the National Museum at Rio de Janeiro shows films of gold which are difficult to account for on any other hypothesis. The specimen was received some thirty years ago from the Danish Collector Claussen, with the indication "gold on limonite, Ponte Grande, Sabará, province of Minas Geraes." The formation at this

place consists of hydromica schists with granular quartzites (itacolumite) and itabirite. The region abounds in old alluvial washings and rock mines in quartz, itabirite and pyrite, those in the latter material being the most important. The geological formation at the Sabará bridge is identical with that of the country rock of the great pyrite vein at the celebrated mine of Morro Velho some fifteen miles away.

The specimen in question is about six centimeters square and two centimeters thick, and consists of white vein quartz. A bit of adhering country rock on one margin shows this to have been a very quartzose micaceous schist. Judging from the appearance, the fragment came from one of the ill-defined and irregular lines of quartz which traverse the rocks of this region generally coincident with the bedding. The lower side, which is almost perfectly flat and seems to have rested on a bed of the country rock, is coated with a thin crust of rusty brown limonite and presents nothing of interest. The other side though flattened is more irregular and had evidently formed one of the walls of a narrow open fissure which had become lined with a crust of black botryoidal limonite less than a millimeter in thickness. The greater portion of the polished surface of this crust is covered with an excessively thin varnish-like film of an iridescent bronzy color. Similar crusts, some of them presenting the bronzy film, line the numerous small cavities of the quartz which appear to have been left by the decomposition of pyrites. Still a third crust or film of reddish brown earthy limonite forms a V-shaped streak about five millimeters broad, at one side of the specimen. This film, though very thin, is of appreciable thickness and rests on the polished surface of the black limonite, from which it may be detached in minute flakes by a very slight pressure with a metal point. On various parts of the specimen, but particularly along the whole length of the V-shaped streak, are minute detached films of gold, the largest of which cover a surface equal to about a square millimeter. These gold films adapt themselves perfectly to all the irregularities of the botryoidal surface of the limonite, and under the microscope are seen to be uniform (not composed of distinct grains joined together) and to present a surface like frosted metal work. The character of the surface is precisely like that of the limonite crust of the V-shaped streak, which, unlike that of the black limonite and of the iridescent film, is not polished. Similar films (as regards adaptation to the irregularities of the limonite and character of surface) were obtained by allowing a drop of mercurial ointment to dry on the surface of the specimen.

We have here, therefore, gold resting on the surface of a secondary mineral (limonite), and in such conditions that it

may be compared to films of limonite deposited from an aqueous solution, or of mercury deposited from suspension in fatty matter. It seems impossible to regard these gold films as transported granules simply lodged against the surface. Their perfect adaptation to the surface on which they rest, their almost inappreciable thickness and their uniformity of structure and of surface, whether large or small, are against this view. In order to judge of the probability of this hypothesis I made the following experiment to determine the state in which fine gold occurs in the rocks of the region. A fragment of arsenopyrite assaying about five ounces to the ton, coming from about 500 meters below the surface in the Morro Velho mine, was dissolved in acid. The exceedingly minute specks of gold obtained in the residue are distinctly granular and crystalline. The smallest, an octahedral crystal, measures 0·075 millimeters, while the largest, an irregular group of crystals, is 0·375 millimeters long. The fine gold of São Gonçalo described in the following article, is of the same character. Such grains could not possibly be lodged against the surface so as to produce films of the appearance of those here described.

The V-shaped streak of earthy limonite shows some peculiarities that seem to throw light on the process of introduction of the gold. Its outer margin is distinctly thickened, showing that the iron-bearing solution stood for some time upon it with a tendency to flow onward, causing a piling up of the liquid at the margin and a consequent thickening of the matter deposited from it. As before remarked, the gold is more abundant on this streak than elsewhere on the specimen, and more abundant on the outer than on the inner half of it, as would naturally occur if it had been deposited from a solution which had been for some reason, dammed back, so as to remain for some time on the place of the streak while it slowly evaporated, as the iron deposit proves to have actually occurred. On removing a little of the iron crust similar films of gold are seen resting on the botryoidal surface underneath the streak. These had evidently been formed before the accumulation of liquid from which the streak was deposited. Some of the gold films outside of the limits of the streak were also most probably deposited at the same time and in the same manner. Of these the greater number occur in a considerable patch, slightly discolored with iron, just below the angle of the V, as if the liquid which deposited gold on the streak had flowed over at this point, that of greatest accumulation, on the adjoining surface, carrying a little iron with it.

The facts above noted appear to be susceptible of the following interpretation as regards the course of events in the history of this specimen. In a narrow open slit of a quartz vein con-

taining pyrites, a crust of botryoidal limonite was deposited lining the walls of the cavity. After its formation this crust became moistened with an iron and gold-bearing solution which deposited the extremely thin film of iridescent limonite (?) and scattered films of gold. Afterward a more abundant supply of liquid gathered and rested for some time, or until it evaporated, in a long, narrow V-shaped band, being prevented from flowing on and spreading evenly over the whole surface by projections of the opposite walls of the slit, or more probably by adhesion to the surface of the limonite; as the liquid slowly evaporated it deposited first its iron, thickest at the margin where adhesion would cause a piling up of the liquid, and afterward its gold, which, instead of spreading evenly over the surface, gathered in certain points by a concretionary action. During the deposition of the iron the upper portion of the liquid, becoming lighter than the lower, flowed over at the lowest point where the accumulation was greatest and, carrying with it gold and a relatively small proportion of iron, produced the thinner film of iron with gold below the angle of the V.

2. Gold in Gneiss.

Gold, almost universally worked from veins or from debris derived from them, is supposed to have come in some way from the adjoining rocks (Dana's Mineralogy, 5th ed., p. 6), but thus far no case of its occurrence in workable quantities throughout the mass of such rocks seems to have been recorded. Museum specimens of country rock charged with gold are comparatively common but in such cases the deposition of the precious metal in the rock is clearly connected with the filling of the adjacent vein. The gold-bearing itabirites of Brazil come nearer to a case of the distribution of gold throughout a rock independent of well-defined veins, but even here the irregular pockets of friable iron ore (*jacutinga*) and lithomarge, in which the gold is found so abundantly, partake somewhat of the nature of veins. The district of Campanha and São Gonçalo in southern Minas Geraes, however, afford an example of extensive mining operations in decomposed gneiss in which the almost complete absence of veins and of the other usual concomitants of gold is remarkable.

This district lies some fifty or sixty miles to the southwest of São João D'el Rei which may be taken as about the southern limit of the rich belt of auriferous slates, quartzites and itabirites which constitutes the best known and most famous mining region of Brazil. In approaching the region from the sea coast one crosses the high gneiss ridge of the Serra da Mantiqueira and then traverses for a distance of fifty

miles or more a high mountainous plateau composed, for the most part, of rounded hills and knobs of profoundly decomposed gneiss. Above these rise several hills and ridges of compact gneiss and at least one ridge of granular quartzite, the Serra de São Thomé das Lettras, mentioned in the preceding article on itacolumite. The quartzite, however, constitutes only a subordinate feature in this region which may be described as almost wholly gneissic; and the accompanying auriferous schists, which characterize the typical gold-mining region of Minas, have not been noticed in this part of the province, though it is probable that they occur. The limits of this mining district have not been traced. Old workings may be seen over a very considerable area all the way from the Rio Verde to the Sapucahy, a distance of twenty-five to thirty miles. The most important centers of the mining operations were, however, the city of Campanha and the village of São Gonçalo, at and between which the following observations were made. Mining has been carried on in this district to a greater or less extent down to the present day, but the most extensive operations seem to have been at about the beginning of the present century. Spix and von Martius, who passed through Campanha in 1818, speak of it as, at that time, a prosperous mining town, the mines having been opened a few years before, while São Gonçalo was already on the decline.

The road from Campanha to São Gonçalo, twelve to fifteen miles long, passes through a region of rounded gneiss hills, so profoundly decomposed that rock is only seen in the beds of the streams and, in a few cases, in the bottom of the old mines. To the eastward there is a high rocky gneiss ridge, known as the Serra das Aguas Virtuosas, from mineral springs at its base, which rises some two or three hundred meters above the general level. To the westward a similar parallel ridge, called the Serra de São José, extends from São Gonçalo about half way to Campanha. These two ridges have a northeast-southwest trend corresponding with the general strike of the rocks of the region. Among the foot-hills of the latter ridge and along a line extending from its extremity to Campanha there is an almost continuous string of old washings often covering several acres and cutting deeply into the hillsides, as extensive as can be found any where in Minas. The feature that particularly strikes the observer accustomed to the deep and narrow open workings, suggestive of railroad cuttings, of central and northern Minas where decomposed vein stuff or thin intercalated beds have been followed, is the great superficial area and nearly uniform depth of the greater part of these old washings. They are suggestive of placers, but on entering them one is surprised not to find gravel heaps and only a comparatively

thin mantle of transported clays at the top, the greater part of the walls and all the bottom being of decomposed gneiss which is evidently *in situ*. The comparative rarity and insignificance of the quartz veins is equally surprising, and when they occur there is no evidence of their having been followed in preference to the enclosing rocks which have been worked away in mass. Indeed the veins are said to be generally barren, though that this is not always the case is proven by one of the mines at São Gonçalo where a little work has been recently carried on along a face twenty feet or more in width traversed by a small vein which affords a richer streak. Some of the hills, as that of the Cata Funda at São Gonçalo, have been worked in ledges or terraces, successive coats of a thickness of a few meters having been more or less completely stripped off as one would peel an onion. In this manner nearly the whole of one side of an elongated ridge a quarter of a mile or more in length had been stripped from base to summit over a width of a few hundred meters. This mode of working is of itself sufficient to prove that the gold was found in workable quantities very generally distributed throughout the mass of decomposed gneiss. This same conclusion is presented in an unpublished report to the Brazilian government by the late Prof. Hartt, who visited São Gonçalo in 1875. Tests made on the clays resulting from decomposition at numerous points selected at random, and on masses of half decomposed gneiss still retaining their form which had been thrown out of a pit, all showed traces of gold and thus confirmed this conclusion.

At São Gonçalo and Campanha the rock is completely decomposed, and it is only by an examination of the clay banks that its original character can be determined. At Santa Luzia, however, about midway between the two places, one of the old workings has uncovered a considerable surface of solid rock in which work was being carried on at the time of my visit. This mine, called Andaime (scaffold), is situated on the top of a hill in which, for some reason, decomposition does not seem to have been so profound as in the other hills of the neighborhood. The older workings show the same characters as those above described; but at present only richer streaks are being followed in the exposed gneiss which, though still retaining its form and stratification, has been sufficiently softened by decomposition to admit of its being easily reduced to a paste with water by the use of crowbars and hoes. The rock is a blackish highly micaceous schistose gneiss, with many thin seams of quartzites, which in places increase to beds of about a meter in thickness. The strata are much contorted, but the general strike seems to be about due east, with a dip of 30° to the south. A small vein of pegmatite traverses the beds. Mining

is at present confined to one of the thicker beds of quartzite which is considered the richest, but very good tests were obtained from the black gneiss and also from loose masses of reddish half-decomposed rock much more feldspathic than that in contact with the quartzite bed. Considerable iron sand was obtained in all these tests.

The washings at São Gonçalo lie on both sides of a small stream that flows near the base of the Serra de São José and parallel with it. On the town side a broad belt over a mile long has been almost continuously washed, and it is said that other washings make with these an almost uninterrupted belt of washed ground as far as the mouth of the stream in the Sapucahy, a distance of about three miles. The washings on the other side of the stream are less extensive, but there is the same tendency to a linear arrangement parallel to the stream and to the Serra, and in the direction of the strike of the rocks. It thus appears that a heavy bed or set of beds is auriferous throughout a thickness of some hundreds of meters and for a distance of several miles along the strike. Although the decomposed material has been very generally washed, traditions speak of richer streaks, and there is some reason for supposing, from the few experiments made, that the more quartzose and ferriferous portions are richer than the generality of the mass. The proportion of gold shown by a single panfull of dirt is very small and the average richness must be very low. I was informed that some recent tests on a measured quantity of dirt gave about fifteen cents of gold per cubic meter.

Owing to the extensive decomposition, there is considerable difficulty in obtaining unaltered specimens of the rock in contact with the auriferous dirt. The only good exposure seen was in the bed of a small stream just below São Gonçalo and near one of the old mines. A panfull of dirt taken a couple of feet above the undecomposed rock gave a color of gold, so that the specimens obtained may fairly be assumed to be auriferous. The rock is here a massive, fine-grained, black and white gneiss, approaching granite in aspect but with a slight tendency to a stratified arrangement in the flakes of mica. The mica is abundant in fair-sized black flakes; the quartz is in small well-formed crystals and is the least conspicuous ingredient, while the feldspar, which is the most abundant of all, is white, a large proportion of it being plagioclase. In the microscopic sections examined, no magnetite or pyrite was detected, but magnetic sand was always found in the tests made of the soft material, and one or two very small crystals of pyrite were found on examining a hand specimen. In view of the almost constant association of pyrite with the gold of the central and northern parts of the province in the auriferous schists,

quartzites and itabirite series, its rarity here is very noticeable. The quartz sand obtained by washing the decomposed gneiss, as well as that from the quartzite bed at Santa Luzia, was in well formed doubly terminated crystals.

The gold of this region is excessively fine. A number of specimens from São Gonçalo and Santa Luzia examined microscopically showed distinct crystalline grains, with sharp, well defined angles. Nothing of a leafy character or resembling the flakes on limonite described in the preceding article were noticed. The grains range in size from 0·05 millimeters for single crystals up to 0·4 millimeters for agglomerations of several crystals, and present the same characters as those obtained by dissolving the arsenopyrite of the Morro Velho vein.

As a company has been recently organized to reopen the São Gonçalo mines by the hydraulic method it is to be hoped that further details regarding this interesting region may soon be obtainable. As already mentioned, a few small gold-bearing quartz veins occur, and in future examinations under more favorable circumstances it may be possible to determine something bearing on the question as to whether or not these veins have been enriched from the adjacent rock.

ART. LV.— *On Colemanite, a new Borate of Lime;* by A. WENDELL JACKSON.

A NEW borate of lime has recently been determined by J. T. Evans, of the California Academy of Sciences. His analysis fixes its formula as follows:

$$2CaO \cdot 3B_2O_3 \cdot 5aq.$$

It differs from pandermite in containing five instead of three molecules of water. Its main interest lies however in its morphological relations. Mr. Evans kindly sent me a crystal for investigation and subsequently I obtained from another source twenty other crystals. They are all small, colorless and in the main with faces in good condition. The examination in the polariscope showed that the crystals were monoclinic. The plane of the optical axes is normal to the clinopinacoid and makes an angle of 83° 25′ with the chief axis (in front).

With a primitive form having

$$\dot{a} : \bar{b} : \dot{c} = 0{\cdot}774843 : 1 : 0{\cdot}540998 \text{ and } \beta = 69° 50' 45''$$

I have determined already the following forms:

Pinacoids: $\infty P\bar{\infty}$, $\infty P\check{\infty}$, 0P.

Prisms: $\infty P\check{3}$, $\infty P\frac{\check{3}}{2}$, $\infty P\check{2}$, $\infty P\frac{\check{3}}{10}$, ∞P, $\infty P\bar{2}$.

Clinodomes: $P\check{\infty}$, $2P\check{\infty}$.

Hemidomes: $\frac{6}{11}P\bar{\infty}$, $6P\bar{\infty}$, $4P\bar{\infty}$, $2P\bar{\infty}$, $P\bar{\infty}$, $-P\bar{\infty}$.

Hemipyramids: P, 2P, $-$P, $-3P$, $-\frac{1}{6}P$, $2P\bar{2}$, $3P\frac{\check{3}}{2}$, $4P\check{2}$, $\frac{1}{2}P\frac{\check{3}}{2}$, $2P\check{2}$, $3P\check{3}$, $-3P\check{3}$, $3P\bar{3}$, $4P\bar{4}$, $-3P\bar{3}$.

The crystals are all highly complex; one of them has twenty-four different forms upon it. At least two distinct types are represented; one in which the basal pinacoid and the hemidome $P\infty$ are largely developed and the other with basal pinacoid and most of the hemidomes either absent or very small. The primitive prism ∞P is largely developed upon all and determines the prevailing columnar habit of the crystals.

ART. LVI.—*On the Decay of Quartzyte, and the formation of sand, kaolin and crystallized quartz;* by JAMES D. DANA.

FACTS from the quartzyte regions of Massachusetts, Connecticut and Vermont fully sustain the observations of Mr. O. A. Derby on itacolumite, published in this volume (page 203), and appear to throw light on the nature of the change producing it.

1. *Sand from quartzyte.*—The occurrence of loose quartz sand and friable sand rock in connection with the Berkshire County quartzyte has long been known, and for many years the product (obtained mostly from crushing the friable rock) has been used for making glass. The most extensive localities and those earliest worked are in the town of Cheshire, a few miles north of Pittsfield, as mentioned in Professor Hitchcock's Geological Reports of 1832 and 1842. The sand-works are situated just west of the railroad station, also one mile and two miles south of it, and two miles to the eastward, near the borders of the town of Savoy. The oldest working is three miles south of Cheshire, and until 1832 it was the only one in Berkshire. At the quarry two miles south of Cheshire village the rock is friable to a depth into the hillside of at least 300 feet; and at this, and other such localities, I have found it unsafe to rely on the present position of the layers for evidence as to the true position, the weakened beds tending to slip out of place by gravity.

I have visited also a locality, formerly worked, in the town of Savoy, about six miles east of the village of Cheshire; and another four and one-half miles east of Dewey's station (Housatonic railroad), near the center of the town of Washington and just south of Ashley Lake. I have found the friable quartzyte also at a kaolin deposit in the quartzyte region of high northeastern Sharon, in Connecticut, and impure varieties at numerous other localities.

2. *Kaolin from quartzyte.*—At the Cheshire sand-works, south of the village, the waters that flow from the quarries, or stand in pools within them, deposit some kaolin over the bottom. The friable rock is well exposed at the quarry two miles south in a bluff front, and between its layers here and there occur thin seams of kaolin; the layers of quartzyte are two to four or five inches thick, and the underlying seam of kaolin usually a twentieth to a fiftieth of an inch; the latter appeared for the most part to have been derived from the overlying quartzyte layer. One layer of quartzyte a foot thick had the kaolin throughout it and was worthless, as the superintendent remarked, for sand-making. A specimen of the kaolin analyzed for the company by Dr. A. A. Hayes, of Boston, afforded 75 per cent of silica to 25 of alumina, equivalent to a half-and-half mixture of kaolin and quartz sand. Similar facts were observed at the works a mile south of Cheshire.

At the sand-quarry in Central Washington, south of Ashley Lake, the quartzyte—which varies in firmness from the hardest to the most friable, from no bedding to thin-bedding—sometimes has the layers alternating with seams of soft kaolinized feldspar; and occasionally this material is so mixed with the quartzyte as not to be easily recognized, except that the crumbled quartzyte is a little coherent.

Many kaolin beds of western New England occur in quartzyte areas. This is true of the largest of these deposits, that in the southwest corner of New Marlborough near the Canaan (Conn.) boundary; the kaolin is sandy and contains fragments of quartzyte; it has bedding from short transportation. It is true also of that of northeastern Sharon, where the kaolin contains much sand and its working brought to the surface the friable quartzyte; also of a small deposit just east of Monument Mountain, between Stockbridge and Great Barrington. The large kaolin deposit of Brandon, Vermont, has quartzyte to the eastward as the nearest outcropping rock, and far the larger part of the clay is white, and thus pure from iron oxide. That of Monkton, Vermont, also a large deposit, is in a sandstone region, independent, says Professor Hitchcock in the Vermont Report (1861), of any limonite bed. That of Pownal, described by Dr. C. Dewey (this Journal, xii, 298, 1827), and spoken of by Professor E. Emmons as "a large bed of porcelain clay," is also in a region of quartzyte.

3. *Feldspathic quartzyte the source of the kaolin.*—Feldspathic quartzyte occurs near the line between Lenox and Washington, in the latter town, two miles east of Dewey's railroad station and four and one-half miles south-by-east from Pittsfield.* Large blocks, evidently derived from a bed in the underlying quartzyte of the region, and cavernous from the removal of most of the feldspar, lie over the field; the narrow ragged cavities are often an inch or more long. Dr. C. Dewey, who describes the

* The locality is south of the house of A. Dexter (situated near the junction between the road from Dewey's to Washington and another short road going north, one-half mile west of the school-house corner), in the field south of the road.

rock in this Journal for 1824 (viii, 17), says of it that "it is wrought into millstones ofter the manner of the Paris buhrstone," and goes by the name of the *Pittsfield buhrstone.* Feldspar exists in some of the cavities. Professor E. Hitchcock recognizes the feldspathic character of the rock in his Massachusetts Geological Report of 1842, saying (p. 587), that the buhrstone is "a variety of gneiss rock whose feldspar has decomposed and disappeared, and in which quartz was greatly the predominant ingredient." The name gneiss given it is not so far out of the way as might at first seem; for some of the rock contains besides the feldspar and quartz a little mica. The hearth-stone quartzyte quarried not half a mile southeast of the locality, which affords the best of hearth-stones of western New England, contains black mica in very minute scales disseminated through it, like much of the quartzyte elsewhere. Professor Hitchcock mentions another locality of it: "four or five miles south of the spot where millstones are prepared," at which the rock "may be seen in all stages of the process between gneiss and buhrstone."

Professor Hitchcock states, in the Vermont Report, that the same kind of feldspathic cavernous quartzyte is common in connection with the quartzyte formation of Vermont, and (p. 343) that bowlders of this variety near Bennington, Vt. (where the eastern mountains are chiefly of quartzyte), were formerly so numerous that "all the feldspar used in the pottery-works was obtained by crushing them and separating from the fragments the crystals of this mineral."

Professor E. Emmons describes the same feldspathic variety of quartzyte in his New York Report of 1842 (p. 159), speaking of it as a rock "in which feldspar exists in small crystals of white or yellowish-white color," that disappear by decomposition leaving a porous quartz resembling buhrstone, and he mentions the town of Pownal, Vermont, as affording it abundantly. He also states in the chapter in his American Geology (vol. I, Part ii), on the Taconic System, that Oak Hill (in northeastern Williamstown and the adjoining part of the town of Adams), which consists of quartzyte with some micaceous and gneissoid beds, has a layer of feldspathic buhrstone-making quartzyte near its eastern foot. At the quartzyte quarry in Sharon, Conn., southeast of the village, I found the quartzyte to graduate into a feldspathic variety which had nearly the characters of granulite; and at a quarry in northeast Sharon, just east of the kaolin locality above mentioned, the same graduation takes place; a specimen of the feldspathic quartzyte received from Mr. J. S. Adam is nearly half feldspar. The feldspar in the quartzyte is cleavable orthoclase as far as I have observed.

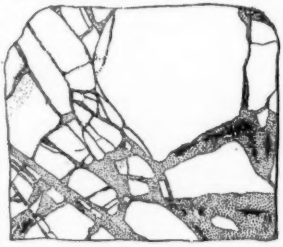
At a locality of kaolin in the south part of Kent, the rock from which the kaolin originated is, as stated by Professor C. U. Shepard in his report on the Mineralogy of Connecticut (p. 74), a kind of "graphic granite which must have been free from mica," in other words, a rock consisting of quartz and feldspar; and at

another, three miles west of New Miford, which the same author describes, the rock is altered in place, the quartz and altered feldspar having the same relative position "as in the undecomposed rock."

The natural conclusion from the above facts is (1) that the porcelain clay or kaolin has come from the feldspar of a feldspathic quartzyte. The quartzyte contained much feldspar and only traces of pyrite and mica, and was easily permeable to water, and hence its fitness for making deposits of pure white clay—such as is not possible from the decomposition of an ordinary mica schist. The black mica of a mica schist contains much iron and even the light-colored muscovite and damourite usually three to six per cent while the quartzyte has almost none and the little oxide that is made is readily removed by percolating waters. No beds of white kaolin of workable value occur with the limonite deposits of western New England which I have examined, although clays abound in them.

It is further evident (2) that the quartz sand and friable part of the quartzyte are produced by the removal of finely disseminated feldspar; while (3) the buhrstones, as Emmons and Hitchcock remark, have resulted where the feldspar is disseminated in largish pieces through the quartzyte.

4. *Pseudo-breccia from Quartzyte, and in some of this pseudo-breccia crystallized quartz.*—A very common source of the destruction of quartzyte is the oxidation of its pyrite, as is well known—a mineral that is often present yet in general very sparingly. One peculiar result of this oxidation is a pseudo-breccia. Specimens of it look like a coarse quartzyte breccia having a ferruginous cement; and Dr. Dewey in 1824 (this Journal, viii, 18), and Professor Hitchcock in his Report of 1841 (p. 588), so call it, the latter remarking that he had not succeeded in finding it in place. It occurs in bowlders in Canaan, Conn., and in many parts of Berkshire, Mass.; and in northeastern Cheshire it appeared to be in place, but characterized only an outer portion of the bed. This pseudo-breccia, as the above figure plainly shows, is a quartzyte that has been divided up by a succession of cracks and has limonite *coloring* the rock alongside of the cracks, and also deposited in them. Many of the pieces, in the specimen figured, lie *in place*, barely separated from one another, and appear to be undergoing new divisions. But in the lower part large pieces look as if there had been wide displacements; yet the hardly disturbed condition of the upper half proves that the apparent displacement is due to the extension of the coloring and penetrating limonite. The cracks are made in part by the extremely slow wedge-like action of the depositing limonite.



The figure represents cavities within some of its dark limonite-

colored bands. This feature I have best seen in the interior of a specimen, about six inches in diameter, found in Canaan, Conn. The cavities occur in all the larger bands. They are generally elongated in the direction of the band, and sometimes are in two narrow lines in a single band, one near each side. The largest cavity is a ragged shallow one two inches long and one inch broad; and another has half these dimensions. These cavities contain a coating of limonite. The prying action attending the oxydizing process tends to loosen grains as well as open crevices; but, if the quartzyte were originally solid, the mechanical removal of the separated grains so as to make cavities in its interior would be impossible. The cavities may have been produced by the removal of largish pieces of pyrite, or of both pyrite and feldspar, but whether so or not, the facts are insufficient positively to determine. The presence of feldspar is rendered probable by the occurrence of a kaolin-like material in a few otherwise empty cavities in the body of the quartzyte.

Further: *the cavities described have generally a lining of minute crystals of quartz;* and these crystals coat the limonite, showing that the crystals were deposited after the limonite. The drusy quartz also penetrates to such an extent the limonite-colored bands, that it is probable that they were formed also during the making of the limonite, and at the ordinary temperature.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Cause of the discrepancy between the observed Electromotive force of a Battery and that calculated from thermochemical data.* — Many voltaic cells have an actual electromotive force quite different from the theoretical electromotive force calculated from thermochemical data. Some of these, those containing iron, nickel or cobalt in a solution of potassium hydrate, for example, show polarization phenomena markedly, as Becquerel pointed out in 1856. These cells, though the positive electrode is unpolarizable, give a current which rapidly falls to zero. So a cell having an electrode of aluminum in dilute sulphuric acid and one of copper in sulphate of copper solution, gives an electromotive force of only 0·62 volt instead of 2·06 volts as required by theory, and a cell having magnesium and platinum plates in potassium hydrate is, contrary to thermochemical data, less energetic than a zinc platinum couple in the same liquid; being 1·35 volts instead of 1·43. Although polarization is generally considered capable of modifying the electrical energy only when a current is produced, yet it appeared quite possible *à priori* that the cause producing this phenomenon might also affect the static electromotive force. Chaperon has accordingly made a series of experiments upon

the polarization of the metals above mentioned, in solutions giving the most marked anomalies. The apparatus was arranged as a decomposing cell, the electrodes being connected with a battery by means of a key which allowed the plates to be alternately put in contact with this battery and with a microfarad condenser. After several alternations the armatures of the condenser acquired nearly the same difference of potential as the maximum given by the electrodes. By means of a ballistic galvanometer or an electrometer, this difference of potential was measured. When the electrodes were of distilled zinc placed in zinc sulphate solution, and called unpolarizable, charged with an electromotive force of one volt, three contacts of the key gave the condenser a charge of only a few hundredths of a volt, which did not increase by further repeating the contacts. But with a polarizable system on the contrary, after three or four contacts, the condenser was found charged to a difference of potential of nearly or quite a volt. On plotting the results in the form of curves whose abscissas represent the differences of potential of the charging source and whose ordinates are the differences given to the condenser by the electrodes, it appears that for the metals and solutions studied, polarizable systems are produced under those circumstances whose difference of potential increases continuously from zero up to the point of decomposition of the electrolyte into its elements. Thus with electrodes of magnesium in alkalies, this electromotive force reaches 3·8 volts and with aluminum in acidulated water, more than 4 volts. Representing by T_{RH} the energy of formation of an electrolyte composed of the elements R and H, by T_{mR} and T_{mH} the electric energy of replacement of the elements R and H by an electrode of polarizable metal *m*, the chemical work corresponding to the electric energy returned by two polarized electrodes will be in general $T_{RH}-T_{mR}-T_{mH}$. Now since the polarization as above shown follows a continuous law of variation, this chemical work may vary in value from T_{RH} to zero; i. e., between the point of electrolysis and the neutral condition of the electrodes; thus giving at the lower limit the equation $T_{RH}-T_{mR}-T_{mH}=0$. So also T_{mR} and T_{mH} may vary from zero to two positive values, each being at the limit, smaller than T_{RH}. It is therefore this limiting value of T_{mR} in the above equation which should be used in calculating the theoretical electromotive force in place of the heat of combination.—*C. R.*, xcviii, 729; *J. Chem. Soc.*, xlvi, 802, Aug., 1884. G. F. B.

2. *On the Color of Chemical Compounds as a function of the Atomic weights of their constituent Elements.*—CARNELLEY has called attention to the fact that the color of chemical compounds depends at least upon three conditions: 1st, the temperature, 2d, the quantity of the electronegative element in a binary compound, and 3d, the atomic weight of the constituent elements. The first two of these conditions were studied by Ackroyd, who observed (1) that all chromium compounds change color in a defi-

nite direction, an increase in the temperature producing tints extending more and more toward the red end of the spectrum, becoming finally brown and black if the heat be sufficiently increased. Ordinarily the color passes from white directly to pale yellow, omitting violet, indigo, blue and green as transition stages. (2) That in binary compounds an increase in the quantity of the negative element produces a change of color toward the red end of the spectrum, ending finally in brown and black; for example, PbO is yellow, Pb_2O_3 red and PbO_2 brown. Carnelley formulates the third condition thus: In certain series of compounds A_xR_y, B_xR_y, C_xR_y, etc., in which R is an element or group of elements, while A, B, C, etc., are elements belonging to the same sub-groups in Mendelejeff's table of natural classification of the elements, the color varies either entirely or partially through the following scale of color as the atomic weight rises: White (or colorless), violet, indigo, blue, green, yellow, orange, red, brown and black; in other words, the higher the atomic weight of the elements A, B, C, etc., the more the color of the compound approaches the red end of the spectrum, becoming in many cases brown or black. Obviously the elements A, B, C, etc., must belong to the same sub-groups. Oxides cannot be compared with the corresponding sulphides, selenides or tellurides, nor fluorides with the corresponding chlorides and iodides. Out of 426 comparisons made by the author, he observed only 14 exceptions to this law. Since the vibration-period of a molecule is lower the less dense its mass, it follows that when this period is less than that corresponding to the violet, no visible vibrations are absorbed and the body is colorless; but as the molecular weight increases, the violet rays are first absorbed and the body appears of the complementary color, greenish yellow; and so on. Increase of temperature, by lessening the cohesion, also diminishes the vibration-period. The author thinks there is some evidence that the color of compounds is a periodic function of their atomic weights.—*Ber. Berl. Chem. Ges.*, xvii, 2151, Sept., 1884. G. F. B.

3. *Gas Analysis under greatly diminished Pressure.*—Lothar Meyer and Seubert have made a series of experiments on the force of gaseous explosion under diminished pressure, the results of which confirm the observation of Thomas that rarefaction produced by diminishing the pressure is more effective in weakening the force of explosion than is dilution with an indifferent gas. In consequence, the authors recommend that the explosions required in gas analysis be made under diminished pressure and they have contrived a modification of the vapor-density apparatus of Schoop to be used for this purpose, the results being rapid, accurate and safe. Experiments to ascertain the pressure at which explosive gaseous mixtures could be fired without injury to the apparatus, showed that for methane and oxygen, the best pressure was 140^{mm}; for propane 80^{mm}; for ethylene 70 to 80^{mm}; for acetylene 40 to 50^{mm}; carbon monoxide 230^{mm}; hydrogen 100 to 125^{mm}. In making an analysis the eudiometer is filled with

mercury in the usual manner and the gas to be analyzed is introduced, in amount about one-tenth of the capacity of the tube. By means of a cathetometer the level of the mercury in the eudiometer and in the barometer is read off. The pressure on the gaseous mixture is then diminished to the required extent by lowering the mercury reservoir and the spark is passed. If there is no explosion, the reservoir is raised a little and a second spark is passed; the normal pressure is then restored and another reading taken. The carbon dioxide formed is then absorbed by sodium hydrate and the volume of the gas is again read. The results are calculated as usual. In a subsequent paper by Lothar Meyer, valuable suggestions are given on the calculation of gas analyses.—*J. Chem. Soc.*, xlv, 581, Oct., 1884. G. F. B.

4. *On the Synthesis of Galenite by means of Thiocarbamide.*—Emerson-Reynolds has shown that the ready desulphurization of sulphur-urea or thiocarbamide by metallic oxides notably those of silver, mercury and lead, may be made use of for the purpose of obtaining their sulphides. When heated with an alkali-solution of lead hydrate, for example, the lead sulphide separates sometimes in a galenoid form yielding a firmly attached specular layer on the sides of the vessel. To prepare the lead solution, 90 grams of sodium hydrate and 75 grams lead tartrate are dissolved in a liter of water. The thiocarbamide solution contains 17 grams per liter. On mixing equal volumes of the two solutions and heating, a brownish color appears at about 38° to 40° C., the whole becomes turbid at about 45° and a specular layer forms on bottom and sides of the vessel, which increases in thickness continually, reflecting light of the same color as a brilliant face of a crystal of native galenite. After ten minutes boiling the liquid is free from any trace of lead. The deposit has the composition PbS: when thin it shows no structure under the microscope; but strong specular layers slowly deposited are seen to be distinctly granular. In the case of some deposits on rough surfaces, brilliant octahedral or tetrahedral faces were observed. The use of this process for plating articles of glass and metal with galenite has already been secured by patent.—*J. Chem. Soc.*, xlv, 162, June, 1884. G. F. B.

5. *On the Action of active and inactive Amyl chlorides and of Amylene upon Toluene in presence of Aluminum chloride.*—Essner and Gossin have shown that active amyl chloride reacts upon toluene with great facility in presence of aluminum chloride yielding a series of products, the chief of which boils between 207° and 209°, gives on analysis the ratio $C_{12}H_{18}$, has a vapor density of 5·54, and is evidently an amyl-toluene. It is a colorless liquid, having an aromatic odor slightly like camphor and has at 22° a density of 0·8679. Oxidized with permanganate, it gave a solution containing only isophthalic acid apparently: though minute quantities of ordinary phthalic and of terephthalic acids were present. The inactive amyl chloride also reacts upon toluene and yields a product boiling at 207° to 209°, which presents all

the properties of the body obtained with the active chloride. Amylene also acts upon toluene in presence of aluminum chloride and gives the same identical product as the active and inactive amyl chlorides. The active chloride under these circumstances loses HCl and becomes amylene, which unites directly to produce tertiary isoamyltoluene. The inactive chloride not only loses HCl but undergoes a molecular rearrangement to yield this body. From the mode of its formation its constitution is easily deduced. It is dimethylethylmetacresylmethane.—*Bull. Soc. Ch.*, II, xlii, 213, Sept., 1884. G. F. B.

6. *On the Electro-magnetic Rotation of the plane of polarization of light.*—A. KUNDT has examined this subject with reference to the magnetic metals in general and his conclusions are as follows:

(1) The greater part of isotropic solid bodies, fluids and gases which have been examined turn the plane of polarization in the positive sense.

(2) A strong concentrated solution of iron chloride turns it in the negative sense. The negative turning of other magnetic salts is apparent from the diminution of the positive turning of the medium of solution.

(3) Oxygen turns the plane in the positive direction.

(4) The plane of polarization of light which is passed through iron, cobalt and nickel is turned in the positive direction.

(5) Negative turning results from perpendicular reflection from an iron magnetic pole. This is true for cobalt and nickel.

(6) With transmission of the rays through iron, as also with reflection from iron, the rotation dispersion is anomalous; that is, the red rays are more strongly turned than the blue.

(7) The complicated phenomena that are seen when light is reflected at an angle from metallic pole pieces of magnets result from the light passing through a thin layer of the metal in which a negative turning takes place.—*Ann. der Physik und Chemie*, No. 10, 1884, pp. 228–252. J. T.

7. *A new form of Polariscope.*—At a meeting of the American Academy of Arts and Sciences, held in Boston, October 8, Professor Edward C. Pickering described a very sensitive polariscope which he has employed to show the varying polarization of the sky at sunset. A double image prism is so placed that the images of an aperture covered with a comparatively coarse grating (made by cutting lines in tin foil), will overlap. The eye-piece is a Nicol's prism which is mounted on a graduated circle. This eye-piece is turned until the images of the aperture disappear, or until the field is of a uniform tint. This instrument can also be used as a photometer. J. T.

8. *Conductivity of Tourmaline for Heat.* — Theoretical conclusions have led Professor S. P. Thompson and Professor O. J. Lodge to believe that there exists in tourmaline a unilateral conductivity for heat in the direction of the principal axis, and that the conductivity in the direction from the analogous pole to the

antilogous pole is different from the conductivity in the opposite direction. Franz Stenger has examined the subject, using an adaptation of Weber's thermo-electrical method, and concludes that the unilateral conductivity for heat in tourmaline is at most extremely small and probably does not exist.—*Phil. Mag.*, Nov., 1884, pp. 427–433. J. T.

9. *Helmholtz's dispersion theory.* — A. WÜLLNER shows from the observations of Langley that the equation between indices of refraction and wave-lengths given by Helmholtz, as the result of his dispersion theory, gives consistent results for the portion of the spectrum examined by Langley. The latter had shown that the equations of Briot, Cauchy and Redtenbacher do not give results consistent with actual measurement.—*Ann. der Physik und Chemie*, No. 10, 1884, pp. 306–312. J. T.

10. *The Infra-red Emission-spectra of Metallic Vapors;* by H. BECQUEREL.—Last year I submitted to the Académie des Sciences a short account of my first researches on the infra-red spectra emitted by metallic vapors, till then unknown.* Since that time I have investigated the subject still further by making use of a special spectroscope, which shall be described in a future paper; I will simply mention here, that the method consists in throwing the spectra, about to be examined, upon a suitable phosphorescent substance, which has been previously rendered luminous, and in observing the temporary excitation, which precedes extinction, under the influence of the infra-red rays. The lines and bands of the emission-spectra then appear brilliant, and can be examined with the microscope.

In experimenting on different phosphorescent substances, notably certain preparations of sulphide of calcium, I found some much more sensitive than others for infra-red rays. These substances have permitted me to determine directly the wave-lengths for the more brilliant lines of several incandescent metallic vapors (potassium, sodium, cadmium), by using the diffraction-spectra produced by a very beautiful metal grating of Mr. Rutherfurd's, which was kindly lent be by M. Mascart.

For other metals, the spectra were obtained by means of a bisulphide-of-carbon prism. The positions of the lines were referred to those of the potassium and sodium lines, and to the positions of the bands and characteristic lines in the infra-red region of the solar spectrum, as well as the absorption-bands of samarium; the wave-length for each line was then determined by interpolation with great accuracy.

The wave-lengths for the lines and principal bands in the infra-red of the solar spectrum have been again determined by means of the grating, which had been placed at my service; and the more sensitive substances in my possession have permitted me to extend these measurements much further than I was enabled to do in my previous researches.† I propose to return shortly to

* Comptes Rendus, t. xcvii, p. 71.

† Annales de Chimie et de Physique, 5e série, t. xxx, p. 5.

this work, which has led me to rectify several numbers relating to wave-lengths at the less-refrangible end of the spectrum; I will only give here the wave-lengths of the principal lines used for reference: the band indicated by A″ in my former memoir is made up of two bands, whose wave-lengths are from 0·00115 to 0·00119 millim., and from 0·001132 to 0·001142 millim.; the large band A‴ extends from 0·001351 to about 0·001400 millim., and the extreme band A^{iv} from 0·001800 to about 0·001900 millim. The wave-lengths of the characteristic absorption-bands of samarium, directly determined, are: from 0·001079 to 0·001097 millim. for the first, and from 0·001239 to 0·001267 for the second.

The metals were volatilized in the voltaic arc. The intensity was such, that I could make use of a very narrow slit, and observe, on the phosphorescent substance, interesting details. In this case, it is necessary that the image of the line be brought to an exact focus on the phosphorescent screen; for, unless this be so, the results are not observable when the slit is narrow. I have not yet been able to invent a suitable arrangement for giving a complete and definite image of the whole of the infra-red spectrum; but, by repeated trials, it was possible to obtain sufficiently distinct images of the groups of lines which are to be examined. I am occupied, however, at the present moment with an improvement, which will admit of still greater delicacy.

Wave-lengths of the Principal Emission-rays of several Incandescent Metallic Vapors.

Potassium.

Wave-length.	
770, 1098, 1162, 1233	Lines very brilliant.

Sodium.

819	Visible to the naked eye. Capt. Abney has photographed this line and discovered that it is double.
1142.	

Strontium.

870, 961, 1003, 1034, 1098	Lines and bands feebler; approximate wave-lengths.

Calcium.

858–876, 883–888	Broad bands, probably groups of lines.

Magnesium.

899	Very intense, perhaps compound.
1047 (?)	Very feeble.
1200, 1212	Broad and perhaps double. This group resembles group *b*.

Aluminium.

1128, 1361·5	Broad and intense, perhaps compound.

Zinc.

1125, 1306	

Cadmium.

1850.	

Lead.

1059·8, 1087, 1133	Very intense.
1221	Feebler group.
1229	Approximate wave-length.

Thallium.

1150.	Approximate wave-length.

Bismuth.

837, 973	Approximate wave-lengths.

Silver.

771, 825	Visible to the naked eye.

Tin

1083, 1199	

The preceding table contains the wave-lengths for the most intense lines, bands or groups of lines which characterize the spectra of several metallic vapors. The numbers are expressed in millionths of a millimeter, and are generally exact to one or two millionths of a millimeter.

Nickel gave several rather feeble bands or groups of lines; while iron, in our experiments, gave no band sufficiently intense to examine.

The results, indicated above, show how rich the field of research is which the phenomena of phosphorescence open up in the invisible part of the infra-red of the spectrum, and which, alone, covers an interval of wave-lengths greater than the visible and ultra-violet parts together.

Besides the interest it may excite by proving the existence of these rays, of which the wave-lengths are considerable, in the spectra of metallic vapors, this research, more than any other, is of the kind which give most valuable information concerning the unknown laws that govern the vibratory motion of incandescent vapors.—*Comptes Rendus*, Aug. 25, 1884; *Phil. Mag.*, Oct. 1884.

11. *Determination of the Wave-lengths of the principal lines and bands in the Infra-red portion of the Solar Spectrum. Note* by M. HENRI BECQUEREL.—In a recent communication to the Académie des Sciences* on the lines in the infra-red part of the spectrum formed by incandescent metallic vapors, I had occasion to point out some corrections which I had been led to make in the numbers adopted in a previous research† for the wave-lengths of several lines and bands in the solar spectrum. I now give a *résumé* of my new determinations of the wave-lengths of the principal lines and bands in the infra-red portion of the solar spectrum.

The infra-red portion of the solar spectrum, from the group A to the extreme end of the visible part, shows, among other things, large absorption-bands. The two more-refrangible ones have already been split up into groups of bands and very fine lines; and it is probable that a more complete investigation would lead to a similar result for the two others. In my former researches I indicated these bands, starting from A, by the letters A′, A″, A‴ and A^{iv}.

The bands A′, A″, A‴ appear to have been observed by most physicists who have examined the infra-red region of the solar spectrum by thermoscopic methods, notably by J. Herschel, Fizeau and Foucault, Desains and Lamansky. The same bands were observed by my father in 1866 by applying methods relating to phosphorescence; but the values (varying considerably among themselves) which different physicists have obtained for the wave-lengths of these rays do not allow of the identification, with any certainty, of the results of their researches. In 1847

* Comtes Rendus, August 25, 1884; Phil. Mag., October, p. 386.

† Annales de Chimie et de Physique, 5^{e} série, t. xxx, p. 5.

Fizeau gave the number 0·001445 millim. for the wave-length of a band which appears to be the band A‴. On the other hand, my father obtained for this same band, by the phosphorographic method, numbers varying between 0·001400 and 0·001200 millim., and gave the number 0·001220 millim. for its most refrangible border. It was therefore necessary to determine these wave-lengths directly by using a grating.

In 1879 Capt. Abney prepared a very beautiful map of the infra-red portion of the normal spectrum; it was obtained by photography, and extended to about the wave-length 0·000980 millim. In my previous researches I was enabled, by the application of phosphorescence, to measure, in the diffraction-spectrum of a grating, to about 0·001000 millim.; but the feeble brilliancy of the spectra did not permit of my going further, and I adopted the number 0·001220 millim. for the most-refrangible border of the band A‴ which can be easily observed in the spectrum formed by a prism. The numbers above 0·001000 millim., published in the paper cited above, were obtained by means of an interpolation based upon this assumption.

In a memoir published in 1883 Mr. Langley deduces the wave-lengths of the bands A′, A″, A‴, A^{iv} from their position in the spectrum formed by a prism by an ingenious method of graduation of his spectro-bolometer; and the numbers obtained by him, starting from 0·001000 millim., differed considerably from those given by our hypothetical interpolation. I then proposed to make these determinations again, by throwing the diffraction-spectra obtained by a grating on phosphorescent substances considerably more sensible for infra-red rays than those which were at my disposal during my former researches. These substances have allowed of my measuring, with a quite near approximation, the wave-lengths of the bands in question, as well as several of the finer lines; the numbers given by these experiments are near enough to those obtained by Mr. Langley with his bolometer, but the delicacy of the method of observation used by me is much greater.

The solar rays, concentrated upon a narrow slit, in the focus of a collimator were made to fall upon a beautiful grating, ruled on metal by Mr. Rutherfurd, which M. Mascart was kind enough to lend me. The rays, brought to convergence by a lens, then transversed a bisulphide-of-carbon prism, of which the edges were at right angles to those of the slit and the lines of the grating, and formed upon the phosphorescent substance a series of oblique spectra, in which the rays of the spectra of different orders were in juxtaposition and not superposed. The slit was sufficiently narrow to allow of distinctly seeing the principal lines of the luminous spectrum; and on comparing the position of the lines and bands in the infra-red part of the first spectrum with those of the known lines in the luminous part of the spectra of second and third order, their wave-length was obtained with an approximation which depended only on the accuracy of the scale-reading.

The following table contains the numbers obtained for the principal lines and bands. These numbers appear exact to within one or two millionths of a millimeter, and may be substituted for those which have been given in the publications of my previous researches.

Wave-lengths of the principal lines and bands in the infra-red part of the solar spectrum, expressed in millionths of a millimeter.

700·4. A.	
771.	
783.	
791 to 796.	
804.	
819. (Sodium).	
830.	
844.	
858 to 862.	Corresponds to a calcium group.
876.	
898 to 900. (Magnesium).	
917 to 920. Band or group of lines.	
934 to 945.	A′. Group of lines and bands very near to one another.
950 to 965.	
968.	
992.	
1025.	
1069 to 1075.	
1115 to 1119.	A″. Group of two bands which appear to be those indicated by Capt. Abney as ϕ_1 and ϕ_2.
1132 to 1142.	
1142. (Sodium).	
1200. (Magnesium).	
1254.	
1354 to 1400. A‴.	Border distinct from 1351. Appears to be the band named ψ by Abney.
1440. Feeble band.	
1510 to 1560. Group of bands.	
1800 to 1880. A^{IV}.	Approximate numbers. This band has been called Ω by Mr. Langley.

The above results show that the phosphorographic method permits, when the phosphorescent substances are properly chosen, of the investigation of the infra-red part of the spectrum as far as thermoscopic and farther than chemical methods. This method has, further, an advantage that the others do not possess, namely, that of giving a complete image, at one time, of the part which is to be studied.—*Comptes Rendus*, Sept. 1, 1884; *Phil. Mag.*, Nov., 1884.

12. *On the Strain connected with crystallization and with the development of perlitic structure.*—Mr. Frank Rutley has given (Quart. Journ. Geol. Soc., July, 1884) some interesting observations on the effect of incipient crystallization and the development of the perlitic structure in producing a state of strain in some vitreous rocks, as shown by the phenomena observed in polarized light. The observations were made upon a section of obsidian from Japan. This showed a considerable number of crystals under the microscope and about each of them the phenomena observed in plain polarized light indicated that a state of strain or tension existed in the glass. This strain may be produced by the formation of the crystals, the glass surrounding them showing double-refraction so caused; or in other cases it may be connected with the development of the perlitic structure, the same phenomena occurring within the perlitic area; or again there may be crystals surrounded by the strained glass and these areas bounded by perlitic fissures. The author concludes that perlitic structure

may be produced in three ways, in each case strain being the primary cause of it; they are: (1) Cooling along minute fissures; this seems to be the usual way where the perlitic structure pervades the whole rock, as in perlites. (2) Cooling around included fragments taken up in a lava flow; this seems to be merely a marginal structure connected with the fragments, and not affecting the rest of the rock. (3) By the tension in the surrounding mass when a crystal is formed; the formation of a crystal not necessarily involving perlitic fission.

The author gives an interesting instance of the development of structures in glass along fissures. He says: "Fifteen or twenty years ago a house was burnt down in the market-place at Dover; a small piece of plate-glass from one of the windows is seen, when closely examined, to be traversed by minute, irregular cracks like those in the artificially cracked, carmine-stained quartz of the French jewelers, known as rubace. When examined under the microscope, between crossed nicols, these cracked surfaces appear to be studded with great numbers of beautiful little spherules with a radiating crystalline structure, each traversed by the usual dark cross. That they follow the cracks is evident, because one has to focus down to them in tracing the crack from the upper surface of the glass downward. They are, however, really circular crystalline films like little flat wheels lying on the cracked surfaces of the glass. The phenomenon is superficial and seems only to follow the cracks. We may feel tolerably sure that the glass was not cracked in this manner before the house was burnt. The cracks are precisely such as would be produced in glass or rock crystal by heat and subsequent immersion in a cold solution; and these conditions would, in this case, be fulfilled by the fire and the play of water from the fire-engines. Whether those little circular crystalline aggregates represent crystallization set up actually *in* the glass, or result from the crystallization of some substance other than that of the glass, introduced in solution into the fissures, I am not prepared to say."

II. Geology and Mineralogy.

1. *The Copper-bearing Rocks of Lake Superior;* by R. D. Irving. 464 pp. 4to, with several colored maps and sections and wood-cuts. U. S. Geol. Survey, Clarence King, Director. Vol. v, of Monographs of the Geological Survey. Washington, 1883. —This Report contains the results of a careful survey of the so-called Keweenian series of rocks, which border the larger part of the western half of Lake Superior from Keweenaw Point to Duluth and from Duluth to Nipigon Bay. The rocks of the Animikie group, about Thunder Bay, are excluded, and referred to the Huronian age; and also the horizontal Lake Superior sandstones between Clinton Point and Duluth, which, with the similar sandstones of the southern half of Keweenaw Point and a coast region eastward, are made to be unconformable and

probably of the age of the Potsdam sandstone. The Report first gives a history of former geological investigations of the region and a full bibliography; and then treats of the distribution of the rocks, their kinds and stratigraphy, and all with great thoroughness. The petrographical part is specially interesting on account of the large amount of eruptive rocks in the Keweenian series, and also the unusual excellence of the colored microscopic illustrations. The basic eruptive rocks of the region are remarkable for their range of variation under what may be considered one type of rock. They are described under Rosenbusch's names—diabase, olivine-diabase, diabase-porphyrite (=porphyritic diabase), melaphyr, gabbro, and olivine-gabbro with anorthite rock. Professor Irving remarks that "all of the kinds, although distinct enough in the field are, lithologically considered, but phases of one kind of work," and all plagioclase-augite rocks, to which "the term 'basalt,' restricted by Rosenbusch to their younger equivalents, might be not improperly used." The diabase and melaphyr occur amygdaloidal, and figures on pages 311 and 326 represent the layers of successive outflows with the lower half solid and the upper vesicular. The gabbros are generally coarsely crystalline and sometimes contain orthoclase; the others are of all grades of texture. The anorthite rock is a coarsely crystalline, grayish-white rock occurring at points on the northwest shore of Lake Superior; it often consists wholly of anorthite, but sometimes has a little augite, and in one section a few grains of chrysolite were present. It occurs as masses cutting black gabbro and has included angular masses in the same rock. The acidic rocks are granite (one small locality); augite-syenyte and granulite or porphyritic granite; quartziferous porphyry, quartzless porphyry and felsyte—which terms mean: felsyte, both quartz-bearing and quartzless (the quartz usually in distinct crystals), and either porphyritic with feldspar crystals or not. The felsyte rocks are mostly of a pale or deep red, purplish red, or brownish red color; they occur at Mt. Houghton, on Keweenaw Point, in the Porcupine Mountains farther west, and on the northwest shore of the lake, and were a source of much material for conglomerates in the Keweenaw series.

The subject of the origin of the minerals in the amygdaloidal cavities and their successive formation, so well investigated by Pumpelly, was not particularly studied by Prof. Irving, and only a statement of Pumpelly's results is given.

The fragmental rocks of the series are made of granitic and felsitic material, and in part of material from the other igneous rocks, but are nowhere true quartzose sandstones; a fact indicating freedom from the long continued assorting action of waves and currents during the slow progress of accumulation such as makes beach and sand-flat deposits along ordinary coasts.

The question whether the Keweenian series is the equivalent of any part of the Cambrian group of Great Britain, or is older than its oldest beds, Prof. Irving leaves undecided, for the good

reason that fossils, the only true criterion of geological age, are absent from the beds, and from all underlying beds; he says, accordingly, only this—older than the Potsdam sandstone and its equivalents. The Cambrian of Great Britain is of great thickness below the equivalents of the Potsdam sandstone; and the question has arisen among those who have considered the subject, whether the Keweenian beds are not the equivalents of the part of the Cambrian below the upper Lingula flags, that is, of the Lower Cambrian and Menevian groups of Great Britain, or of the Lower Cambrian alone. Should either prove to be a fact, the series is true Cambrian; and if the name Cambrian is to be used at all in American geology, this series may claim it better than any beds of later origin.

The colored maps of the Report are of the best style of the art, and the other illustrations are excellent.

2. *Note on the Paramorphic Origin of the Hornblende of the Crystalline Rocks of the Northwest;* by R. D. IRVING.—In my second paper on this subject in this Journal for February, 1884, in which I give an historical review of the matter, there is a quite important omission. In referring to the work of Streng on the Minnesota crystallines I failed to note that, besides the Duluth gabbro, Streng had described other rocks from Minnesota* in a number of which he found associations of augite and diallage with hornblende, of such a nature as to lead him to believe in the secondary origin of the latter. It is evident that Streng was by far the first to note this relation between hornblende and an augitic material in the rocks of the Northwest; not merely in greenstones but in granites and other quartz-bearing rocks. And not only this, for he describes *single* brown hornblende (with cores of diallage), which he evidently regards as altered from *single* diallages, though he speaks cautiously on the subject.† His words in conclusion are worth quoting:

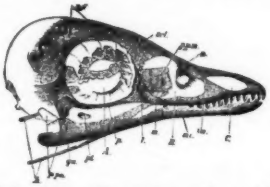
"Das augitische Mineral ist überall als Diallag ausgebildet, dessen deutlichste Spaltfläche die stumpfe Säulenkante der es umhüllenden Hornblende gerade abstumpft. Die Verbindung beider Mineralien ist eine so unregelmässige, die Hornblende dringt in so schmalen Parthien in die Augitsubstanz ein, dass man sich des Gedankens nicht erwehren kann, hier sei die Hornblende aus dem Augit entstanden. Der Beweis für diese Ansicht wird aber erst erbracht sein, wenn es gelingt nachzuweisen, dass die äussere Umhüllung des ganzen Krystalls die Form des Augits an sich trägt. Würde dieser Beweis gelingen, dann würde man annehmen müssen, dass auch andere Hornblenden, welche keinen Augitkern mehr besitzen, aus Augit entstanden sein und dass bei ihnen die Umwandlung schon vollendet sei; d. h. dass die fraglichen Gesteine einstmals noch reicher an augitischem Minerale gewesen sein, als sie jetzt erscheinen." This was in 1876.

Madison, Wis., Oct. 7, 1884.

* Neues Jahrbuch für Mineralogie etc., 1877, pp. 31–56, 113–138, 225–242.

† Neues Jahrbuch, 1877, p. 240. See also for translation Eleventh Annual Report Geol. Survey Minn., p. 84.

3. *The Berlin Archæopteryx.* — The Geological Magazine for September last contains an abstract of a paper by W. Dames on the Archæopteryx discovered in 1877 in the lithographic stone at Blumenberg in Bavaria (the same rock that afforded the specimen described by Professor Owen), which is illustrated by a plate showing the head with the tooth-bearing jaws, from which the accompanying figure of the head is taken, reduced in size. The



A, orbit; *B*, antorbital foramen; *C*, nasal opening; *pf*, parietal and frontal; *n*, nasal; *im*, intermaxillary; *l*, lachrymal; *m*, maxillary; *p*, palatine; *ppm*, palatine process of maxilla; *pt*, pterygoid; *qu*, quadrate bone; *scl*, sclerotic plates of eye; *mi*, lower jaw; *ppa*, post-articular process of mandible; *h*, hyoid bones.

length of the head is about two inches. When examined by Carl Vogt and Professor Marsh only two of the teeth were visible. By the removal of the rock, 12 teeth in a row are now exposed from the extremity of the beak backward out of the original number 13. The edge of the jaw carrying the teeth is 16^{mm} long; and the teeth, which are very nearly alike in size and shape, measure 1^{mm} in length and 0·5 in width. On the lower jaw, portions of only three teeth are visible, but enough to make it almost certain that the teeth of the jaw corresponded with those in the upper. The length of the jaw is 35^{mm}. The evidence seems to prove that the teeth are implanted in distinct alveoli.

The author states that the skeleton appears to be more closely connected with living birds than with the toothed birds of the Cretaceous period described by Marsh.

4. *The deposition of Ores;* by J. S. Newberry, (School of Mines Quarterly for May, 1884, New York).—Dr. Newberry's extensive knowledge of the ore deposits of western North America gives great weight to his conclusions as to their positions and origin. In this valuable paper he discusses the bearing of the facts he has observed on the theory which attributes the origin of the ores to the leaching of adjacent *igneous* rocks. He shows, by a mention of many examples, that different sets of fissure veins widely diverse in character cut the same country rock; that the same vein often traverses a series of distinct formations without any essential change; that many veins have no connection with any igneous rock; that the most extensive igneous ejections have no associated ore deposits; and favors the view of Richthofen that the filling of many of the veins was the result of "the leaching of deep-seated rocks, perhaps the same that enclose the vein above, by highly heated solutions, which deposited their load near the surface." The region, he observes, is conspicuous for the number of its hot springs, and it is evident that these are the last of the

series of thermal phenomena connected with the great volcanic upheavals and eruptions since the beginning of the Tertiary age." The heated moisture of the Comstock lode is heated by coming in contact with hot rocks at a lower level than the present workings, and the hot sources thus opened are doing to-day what they have been doing in the past, though less actively—bringing toward the surface the materials taken into solution in a more highly heated zone below. Hot, not cold, waters are doing and have done the chief part of the work in the formation of mineral veins.

5. *Some instances of Atmospheric action on Sandstone;* by M. E. WADSWORTH. (Proc. Boston Soc. Nat. Hist., vol. xxii, Feb. 7, 1883.—The object of this brief paper is simply to place on record some observations made a number of years ago, and to call the attention of others to the subject, in the desire that similar facts may be observed and more fully studied elsewhere.

That ordinary atmospheric agencies produce a greater effect upon rocks of a siliceous character than is generally believed, I have long deemed probable. This conclusion has been derived from field observations, especially upon sandstone and quartzites.

As examples of the power of the ordinary atmospheric agencies over rocks I would cite some cases observed by me in 1871, '72 and '73 near Mazomanie, Wisconsin, in the friable St. Peter's and Potsdam sandstone. The St. Peter's sandstone is composed almost wholly of a pure quartz sand, and in the outliers of it found on the hilltops south of the town, the parts covered by the soil were more or less friable and the grains distinct; while the exposed portions of the same blocks and slabs were greatly indurated, the grains almost obliterated, and the rock possessed the conchoidal fracture and other characteristics of a quartzite.

The Potsdam sandstone east of the town likewise possessed similar characteristics. In this, concretions of an indurated character were found forming on the surface, in size from three-fourths of an inch to an inch in diameter; while in the sandstone a few inches only, their rudiments could be observed in minute spherules, and a few inches farther in the sandstone was incoherent, easily crumbling under the touch and showing no trace of concretionary structure. At another locality the sandstone showed in cavities formed by weathering a distinct lining of quartz crystals, while a few inches beneath the surface the rock had the common friable character. The formation of these crystals, as well as the surrounding surface induration of the rock, is to be attributed to atmospheric agencies; as hot waters would have consolidated the sands beneath, and not as is seen extensively in that vicinity only the surface rock left by denudation. In the autumn of 1872 a block of clear white Potsdam sandstone was found on the side of a hill, the protected side of which was friable, while the other sides, especially the one most exposed to the prevailing storms, was nearly a quartzite. This block was only about two feet square, and as a test of the correctness of the above conclusion the indurated surface was broken off, and a

comparatively friable surface exposed. This locality was visited the following spring when it was found that this fresh surface was much indurated and approached toward a quartzite.

This change had taken place in the few months that had elapsed since the fractured and friable surface had been exposed and there could be no doubt that the change was due to the action of the elements. Many observations were made regarding the induration of these sandstones, which are not here given, but all tended in the same direction—to show that atmospheric agencies exercised a strong indurating influence upon the surface and immediately underlying portions.

6. *On the Structure of English and American Carboniferous Coals;* by EDWARD WETHERED, F.G.S., F.C.S. (Brit. Assoc., Montreal Meeting, 1884.)—With a view of testing the "Spore Theory" of the origin of coal, as propounded by Professor Huxley, the author had obtained a portion of the "better bed" seam intact for a thickness of ten inches from the top. He had examined this inch by inch, by preparing thirty-three microscopic sections. At the top was three and one-half inches of dull lustrous coal, termed "laminated coal." This the author found to be practically a mass of macrospores and microspores. Below this there was a change in the character of the seam. Spores became less numerous; in places they were scarce, the mass being made up of vegetable tissue and a substance to which the author gives the term "hydrocarbon." He could not, therefore, support Professor Huxley in saying that the "better-bed" coal was "simply the sporangia and spore cases of plants." The assertion would, however, apply to the first three and one-half inches of the seam. The "splint coal" from Whitehill Colliery was a better example of a spore coal than the "better-bed." The bottom stratum was four inches thick, and presented a dull luster with thin bright layers traversing at intervals. The dull portion was a mass of spores and spore cases, but these did not enter the bright layers. A vertical section cutting a bright layer, bounded on either side by dull lustrous coal, showed plenty of spores in the dull coal, but in the bright not one was detected. The second bed in this seam was one foot thick; it was of a brighter luster than the four inches below, but two layers could be distinctly made out, one more lustrous than the other. In the dullest of the two spores were found, which, however, were less numerous than in the bed below, and were, also, of a different variety. In the bright layers the spores were absent. The top bed of the seam was also one foot thick, and might be defined as a mass of spores, chiefly microspores, except in the bright layers. The American coals examined were collected by the author from the Warrior Coalfields of Alabama, and from near Pittsburg, Pennsylvania. The same structural affinities were noticed as in the English coals, and the author therefore came to the conclusion that the English and American Carboniferous coals had a common origin.

The spores in the coal from both countries were closely allied.

Some microspores from Alabama were identical with those which occur in the lower bed of the Welch "four feet" seam. A feature in spores obtained from all the coals was the triradiate markings which they exhibited. Whether this was to be regarded as superficial or not, it was very characteristic of them, and was, therefore, to be considered in attempting to ally them with modern vegetation.

7. *On the Geology of South Africa;* by T. Rupert Jones, F.R.S., G.S., etc.—The contour of the south coast is parallel with the outcrop of the strata in the interior, from Oliphant's River (31° 40′ S. lat.) on the west coast, southward to the Cape, and then eastward to about 33° 30′ S. lat. Here the edges of the strata, formerly bending round to the north, have been swept away to a great extent; but their outcrop is again seen on the east coast at St. John's River (31° 40′ (S. lat.), where they strike northeastwardly through Natal, probably far up the country.

(1.) Gneissic rock and the *Namaqualand Schists* apparently underlie the others, coming out on the northwest, and exposing a narrow strip on the south coast. (2.) Mica schists and slates, interrupted by granites here and there, form a curved maritime band, from about 30 to 70 miles broad, and are known as the *Malmesbury Beds* (Dunn). These and the beds next in succession (the *Bokkeveld Beds*, 3) are overlain unconformably by the *Table-Mountain Sandstone* (4), 4,000 (?) feet thick, which forms patches and extensive ridges, and possibly dips over No. 3, to join No. 5, the *Witteberg Beds*. Nos. 3 and 5, together about 2,100 feet thick, lie parallel, and form a concentric inner band. The former contains *Devonian* fossils; the latter is probably of *Carboniferous* age (with *Lepidodendron*, etc.), and forms the Wittebergen and Zwartebergen in the Cape district, and the Zuurbergen in Eastern province.

The *Ecca Beds* (6) come next; Lower series, 800 feet; Conglomerate beds (*Dwyka*), 500 feet; Upper series, 2,700 feet; conformable with No. 5; in the south much folded, and in undulations throughout, until it passes under the next set of beds, No. 7, in some places 50 miles to the north. The Ecca beds have fossil wood and plant remains in abundance here and there, but these have not been clearly determined. This series has not been well defined until lately, and even now its limits are not fully determined. It includes the Karoo Desert, and therefore takes in the lowest members of Bain's great *Karoo formation*, Nos. 12 and 14 of his map (1856), or the 'Ecca,' 'Koonap,' and part of the 'Beaufort' beds of Jones (1867). The series No. 7, horizontal and unconformable on the Ecca beds at the Camdeboo and elsewhere, retains the name of *Karoo Sandstones;* and, after a width of about 40 miles, is conformably surmounted by a set of somewhat similar beds (8) in the Stormberg; and thus No. 7 should be regarded as the *Lower*, and No. 8 the *Upper Karoo sandstones*. The latter end off northward in the Draakensberg, Natal, Orange-Free-State, the Transvaal, and Zululand, with the

still horizontal *Cave sandstone* and associated beds. The *lower Karoo sandstones* probably thin away northward beneath the others. Below the *Karoo sandstones*, and dying out southward near the Cambdeboo (Professor Green), are the Shales (7*), which constitute the country around Kimberley, described as the 'Olive shales' of the Karoo Formation,' by G. W. Stow. These die out northward against the old rocks of Griqualand-West and the Transvaal. They contain Glacial conglomerates in their lowest (earliest) beds, in Griqualand-West, just as the Ecca series has its great Glacial conglomerate (the *Dwyka Conglomerate* in No. 6) in its lowest portion. As the *Stormberg beds* (8) lie upon the *Olive* or *Kimberley shales* (7*) in the Orange-Free-State, the *Lower Karoo sandstones* (7) must die out northward. The *Kimberley shales* contain some reptilian bones and plant remains, and some coal on the Vaal; the *Karoo sandstones* are rich with Dicynodont and other reptilian bones, and have some fish remains; and their upper portion (*Stormberg*) contains Ferns and Cycadeous leaves, and some seams of coal. A fossil mammal also has been found in this series. Throughout its range the *Karoo Series* is traversed with igneous dykes.

Limestones and sandstones (9) with fossils of nearly pure Jurassic, but with some of Cretaceous type, occur unconformably in the Eastern province. Their fossil flora is like that of the *Stormberg Beds.* Cretaceous strata (10) are known on the Natal coast; and Tertiary and post-Tertiary deposits (11) from several patches on the east, south and west coasts.

8. *Miniature domes in Sand.*—Mr. T. Mellard Reade, in the Geological Magazine for January last, describes domes of sand 3 inches across and ½ an inch high, resting on blue clay, on a smooth sandy shore, which he attributes, with reason, to a lifting of the sands by air imprisoned between the clay and the moist surfaces of the sand; water, percolating, from the line of cliff 6 to 10 feet off, along the clay forcing the interstitial air upward into a flat bubble and raising the sand above. Mr. Reade states that on trial he found that a bottle holding 7 ounces of *perfectly dry* sand well shaken together would hold in its interstices 2 ounces of water, the ratio of sand to water in bulk being, therefore, about 7 to 5.

9. *A Treatise on Ore Deposits;* by J. Arthur Phillips. 652 pp. 8vo, with numerous illustrations. London, 1884, (Macmillan & Co.)—The author of the well known Manual of Metallurgy, presents in this new work a general account of the various kinds, and modes of occurrence and associations, of ore deposits, a review of theories as to the formation of mineral veins, and special descriptions of the principal mining regions of the world. A comprehensive work of the kind has been greatly needed, there being none in the English language of more recent date than Professor Frederick Prime's translation of the volume by Von Cotta. The work fulfills well its purpose both as an elementary and descriptive treatise. The part on the mines of the United States and Mexico

is the least satisfactory. It covers but 60 pages, which is a small allowance considering the variety, extent and peculiar character of the ore-deposits. Mr. Phillips's visit to the country some years since has aided him in writing up the subject; but another visit, preparatory to the present treatise, would have secured for it greater thoroughness and precision, since the new developments during the past decade have been great.

10. *Lesquereux on the Coal Flora of Pennsylvania and the United States.*—The third and last part of the Coal Flora of the Pennsylvania and the United States, by Leo Lesquereux has been published, as volume III P, of the Reports of the Second Geological Survey of Pennsylvania. It is a fine volume of 280 pages with 24 8vo. plates, completing the work in 976 pages and 111 plates. The first two parts, published in 1880, have been widely distributed and are now well-known. This last one adds descriptions of a large number of very interesting new species, the most of them figured, some corrections and additions to a few of the species already published, a table of species referred to formations, an enumeration of all the species found at each locality mentioned, and a revised index for the three volumes of generic and specific names referring both to pages and to plates.

11. *Lithological Studies: a description and classification of the Rocks of the Cordilleras;* by M. E. WADSWORTH. 208 pp. with 33 pp. of analyses and 8 plates. 4to. Cambridge, 1884 (Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xi, Pt. I).—This work as stated by Professor J. D. Whitney, in an introductory note, is a continuation of the publications of the Geological Survey of California begun in 1860. The part already published, however, is only in small part devoted to the description of Californian rocks, but is in fact principally a discussion of meteorites. It contains an extended discussion, in the successive sections of chapter I of the structure of the earth, the origin and alteration of rocks, and of their mineral constituents, the value of chemical analyses of rocks, the methods of classification based upon mineral composition, geological age, with the conclusions adopted by the author as to the true method of lithological classification. Chapter II takes up the siderolites and pallasites; chapter III the peridotites, and chapter IV the basalts. The "rocks" described under the above heads are mostly meteorites and the author has collated with much thoroughness the results of the investigations of others and has added to them observations of his own. In regard to the origin of meteorites, he regards "the sun, or some similar body, their most probable source." The tables in the close of the volume, covering pages 1 to 33, contain a long series of analyses of chromite and picotite, showing their close relation to each other, and also of meteorites and terrestrial rocks, mostly the former. The colored plates are well executed.

12. *Carboniferous Cockroaches and Myriapods.*—Professor S. H. Scudder has a paper in the Memoirs of the Boston Society of

Natural History, vol. iii, No. ix, (March, 1884), on new species of Cockroaches of the genus *Mylacris*, and on Myriapods of the genera *Trichiulus* and *Palæocampa*. The Myriapods are from Morris, Illinois, and the Cockroaches from Pittston and Cannelton, Pennsylvania and Morris, Illinois. In view of the characteristics of Palæocampa, it is remarked that, although so ancient and peculiar a type, the dermal appendages are of extraordinarily high organization, and further that the divergencies of structure among Carboniferous Myriapods was as great as among existing species. No trace of Myriapods has been found in this country below the Carboniferous; but they are known from the Old Red sandstone of Scotland.

13. *Macfarlane's Geological Railway Guide.*—JAMES MACFARLANE, Towanda, Pa., has commenced revising his American Geological Railway Guide for a second edition. He would be glad if persons who have used the book and made notes of corrections and additions, would send them to him; or if it will be a saving of labor, it will be a great favor to him if they will send him their copies of the book by mail, which he will return and refund all postage.

14. *On the Composition of Herderite.*—The doubt in regard to the true composition of herderite (pp. 318 and 401 of this volume) has at length been removed by Dr. Genth. The results of his analytical work, recently published, confirm those first given by Mackintosh and go to show that Winkler's are entirely untrustworthy. Four analyses were made by Dr. Genth upon quantities of the mineral, respectively, 1·033, 0·8608, 0·3303, 0·5860 grams, and the results are given below, together with the analyses by Mackintosh and Winkler.

	Stoneham.						Ehrenfriedersdorf.
	I	II	III	IV	Mackintosh.	Winkler.	Winkler.
P_2O_5 =	41·76	43·01	43·38	43·43	44·31	41·51	42·44
BeO =	14·60	15·01	15·17	15·04	15·76	14·84	8·61
Al_2O_3 =	0·17	0·22	0·09	0·20	....	2·26	6·58
Fe_2O_3 =	0·48	0·31	0·49	0·15	....	1·18	1·77
MnO =	0·09	0·08	0·12	0·11	....	....	....
CaO =	33·96	34·06	33·74	33·65	33·21	33·67	34·06
H_2O =	....	....	?0·61	?0·61	....	6·59	6·54
Fl =	....	?6·04	....	8·93	11·32	....	....
				102·12	104·06		
Less O =				3·76	4·76		
				98·36	99·84		

Dr. Genth gives in detail the method of analysis followed by him, and in conclusion says:

"The analysis made by Mr. Mackintosh and myself show that herderite is anhydrous beryllium-calcium phosphate and fluoride—with traces only of alumina and ferric oxide and perhaps water. The traces of alumina are owing to slight admixtures of traces of mica and albite.

"Somewhat doubtful is the exact quantity of fluorine which it contains. Mr. Mackintosh determined its quantity from the excess of lime which he found. A determination which I have made in the same manner gave me a far lower result, instead of 11·32, only 8·93 per cent. My direct fluorine determination is probably too low, owing to the incomplete decomposition of the mineral by fusion with silica and sodium carbonate and the difficulties in the separation of fluorine from such a solution. A doubt also exists as to the 0·61 per cent loss by fusion with plumbic oxide, whether it is water or lead fluoride. As all my material was used up I could not attempt any other determination for clearing up these doubtful points.

"It is to be regretted that the results of Dr. Winkler's two analyses are so very unsatisfactory, and that he has sacrificed the very precious Ehrenfriedersdorf herderite by employing incorrect methods for his analyses. By ignition he has volatilized the greater portion of the fluorine, then by evaporation with nitric acid the rest may have gone (although nitric acid is less liable to drive off hydrofluoric acid than hydrochloric acid would be); therefore, when he subsequently tested for fluorine, there was no more left than sufficient to give a *doubtful reaction.* * * *

"Dr. Winkler does not state that he has tested his so-called *alumina* for its purity, which is unfortunate, or he would have found that a slight trace of it might have been present, but that the precipitate was nearly pure glucina. There can be very little doubt that the Ehrensfriedersdorf and Stoneham mineral are identical in composition. There is also a larger percentage of ferric oxide in Dr. Winkler's analysis than found by me. Might this not have come from the molybdic acid which he used? The ammonium molybdate—prepared from Merk's molybdic acid—which I use contains in 100^{cc}, 0·002 grms. ferric oxide. As I used measured quantities a corresponding amount of ferric oxide was deducted."

III. Botany and Zoology.

1. *Catalogue of the Flora of Minnesota;* by Warren Upham. Part VI of *Report of Progress of the Geological and Natural History Survey of Minnesota*, N. H. Winchell, State Geologist. Minneapolis. 1884. pp. 193, 8vo.—"Minnesota lies in the middle of the North American Continent, almost midway between the Atlantic and Pacific oceans and between the Gulf of Mexico and the Arctic Ocean, being distant a thousand miles or more from each of these grand bodies of water. . . . It lies between 43° 30′ and 49° north latitude, and between 90° and 97° west longitude. Its area is 84,286 square miles." "A moderately undulating country" on the whole, with an average elevation of about 1,275 feet above the sea; its lowest land, on Lake Superior, 602 feet above the sea, its highest is the Mesabi Range in the northeast, not far from that lake, which exceeds 2000 feet, while Itasca Lake, the head of the Mississippi, is about 1500 feet above the

sea, and that river at the southeast corner of Minnesota, 620 feet. "The warmest days of summer have a temperature of about 90° Fahr., but such days are rare; and the greatest cold of winter is −30°, or sometimes −40°. The annual precipitation as rain and snow is from 25 to 30 inches. . . . The soil throughout the greater part of Minnesota consists of glacial drift. . . . Forest covers the northeastern two-thirds of the State, approximately, while about one-third, lying at the south and southwest, and reaching in the Red-river Valley to the international boundary, as also the part of the valley farther north to Lake Winnepeg, is prairie." The three pines of the State are the Jack Pine, *P. Banksiana*, in its most favorable growth attaining 40 to 60 feet in height, but seldom exceeding a foot in diameter, good for fuel and not bad for railway ties; Red Pine, *P. resinosa*, 50 to 75 feet high but seldom over a foot in diameter, yet "it is considerably sawn for lumber" and used for piles, etc.; White Pine, *P. Strobus*, "common through the north half of the State," excepting at the west, "the largest as well as most useful of our trees, growing from 80 to 125, rarely 150 feet in height, and from 3 to 6 feet in diameter." There is also Black Spruce, a very little White Spruce, a very few trees of Hemlock Spruce, some Balsam Fir, very little Red Cedar large enough to be forest trees, and a good abundance of Larch and Arbor Vitæ. The grass of the prairies consists mainly of *Andropogon furcatus*, *Chrysopogon nutans*, *Bouteloua racemosa*, and *Stipa spartea:* in wet ground *Spartina cynosuroides* and *Leersia oryzoides* make the principal hay. "About eight per cent of the plants growing without cultivation in the State are introduced species." All this, and much other information we find in the well-arranged preface; which, moreover, opens with a history of the various publications touching the Minnesota flora, from Hennepin and Carver down to date. There is a good map, illustrating the distribution of prairie and forest, and the principal components of the latter. The catalogue is excellently planned and executed, very well printed, full of good observations, and characters are given in foot-notes of all species and genera which are not described in Gray's Manual, so that these two together supply the student's needs. From the "Review" at the end of the volume, we gather that 1650 species of Phænogamous and Vascular Cryptogamous plants are enumerated, belonging to 557 genera, and to 118 orders. The six largest orders are *Compositæ*, *Cyperaceæ*, *Gramineæ*, *Leguminosæ*, *Rosaceæ*, *Ranunculaceæ*. Deducting the introduced plants, 138 in number, the indigenous staple consists of 1512 species, in 502 genera and 117 orders. It is reckoned that 290 of the indigenous species are also European. This catalogue "claims to be merely a report of progress in an unfinished work." It makes good its modest claim. A. G.

2. *Repertorium Annuum Literaturæ Botanicæ Periodicæ*, curavit G. C. W. Bohnensieg, Custos bibl. Soc. Teylerianæ, Harlem.—This elaborate and well-digested index and guide to botanical publications in periodicals is still kept up with spirit by

the Teylerian Society. We have now received the seventh volume, of 522 pages, 8vo, with full indexes of names of authors and of genera of plants treated; this for the year 1878. With it, the first part of the eighth volume, of 211 pages, for a portion of the bibliography of 1879. The arrangement is clear and the elaboration thorough. A. G.

3. *Drugs and Medicines of North America; a Quarterly, devoted to the Historical and Scientific Discussion of the Botany, Pharmacy, Chemistry and Therapeutics of the Medicinal Plants of North America, their Constituents, Products, and Sophistications.* J. U. LLOYD, Commercial History, Chemistry and Pharmacy, C. G. LLOYD, Botany and Botanical History. Cincinnati, J. U. and C. G. Lloyd, 1884.—The title page on the cover specifies the nature and scope of this work. The form is imperial 8vo. The three parts of the first volume, now before us, bear the dates respectively of April, July and October, reaching to 96 pages. The fullness of the work may be judged of when we state that these pages are devoted to one natural family, the *Ranunculaceæ*, and that by no means completed. *Clematis Virginiana* begins the first part, *Hydrastis Canadensis* fills the larger part of the third. There are good figures. The second figure of *Clematis crispa* ought to be good, for it is copied from the best original figure extant, and the same may be said of others. There are some elaborate magnified views of microscopical sections. We are struck with the wonderful fullness of the historical and bibliographical matters, also with the statistics or general statements of the enormous amount of some of the herbs and roots which have been collected and sold. For instance, in about the year 1880 a great demand for Hepatica sprung up, and during the year 1883, one State supplied more than 30,000 pounds of the dried leaves of this plant, and it is estimated that 450,000 pounds were gathered or imported for our home market; all this of a plant which is essentially inert. And the total yearly collection of the root of *Hydrastis* "will not vary much from 140,000 or 150,000 pounds." At this rate an interesting and peculiar genus would before long be extinct. A. G.

4. *Das Botanische Practicum;* by Professor STRASBURGER. pp. 664. Jena, 1884, 8vo.—Taken all in all, this is the most remarkable hand-book in practical vegetable histology ever published. From beginning to end the directions are explicit and ample, in respect both to the sources from which material can be procured, and the treatment to which it must be subjected in investigation. The range is very wide, embracing all types of plants, giving to each a due proportion of space. Therefore, if a student goes carefully and faithfully through the whole treatise, he will be placed in possession of the more important facts relative to the structure, development, and growth of all classes of plants. But it is not alone the extent of the scheme of study which attracts attention; the extreme care with which every difficulty in the path of the independent student is either smoothed down or removed, is a

distinguishing feature of the book. Lastly, it must be said that it is in no sense a compilation. From first to last, it is constructed from new and fresh material, and by a master, whose name is associated with the successful treatment of the most difficult problems in vegetable morphology and histology. His recent contributions to our knowledge of the division of the nucleus are here given as if in his own laboratory, and the details are as minute in every respect as the most exacting student could possibly demand. A single illustration must suffice. In speaking of the fertilization of gymnosperms, the material for study is fully described, so that any one can know just how and when to select it, and how to preserve it for examination. Then follow full directions as to proper methods of dissection. It is as if a painstaking teacher were at the side of a pupil, showing him step by step how to advance from the most elementary to the most difficult parts of his subject. Those who are familiar with Strasburger's classical works on the division of the cell and on the cell wall must have felt that there is a lack of method in presenting the wealth of material, and that the author is sometimes apt to conjoin accounts of methods and results without sufficient attention to the requirements of the style naturally looked for in a scientific treatise. But this habit of thought lends a great charm to these discursive and almost colloquial conferences with the pupils, whom he takes into his confidence in this admirable guide. It is to be hoped that the promised English translation will be as well done as are the translations of some other recent German botanical works. G. L. G.

5. *The Essentials of Botany;* by Professor C. E. Bessey. pp. 292, 8vo.—This is an abridgment of a useful work by the same author, published in 1880, and already noticed in this Journal. In the abridgment, two changes have been made to adapt it to a younger class of pupils than those for whom the earlier volume was designed; first by replacing many technical terms by simpler equivalents; second, by furnishing hints as to progressive laboratory practice. Both of these steps are in the right direction. The volume is clearly written, and is quite abreast the recent advances or changes, both in structural and systematic botany. A considerable amplification of the directions for practical exercises would doubtless increase the usefulness of the work, since such practical exercises, faithfully followed by teacher and pupil, form the best introduction to the study of any branch of natural history. G. L. G.

6. *Ornithorhynchus and Echidna.*—The announcement of the discovery of oviparous reproduction in the Monotremes by Mr. W. H. Caldwell, made before the British Association at its Montreal meeting, is published in the South Australian Register (of Adelaide) of September 5, as a telegram from London; and in the same paper occurs a notice of the meeting of the Royal Society of South Australia, on Tuesday, September 2, which notice contains the statement that "Dr. Haacke laid a number of specimens on

the table, including an egg found in the pouch of a female Echidna, in support of the theory that the Echidna, although a milk-giving animal, lays eggs which are hatched in the pouch." In the same paper, of the 6th, Dr. Haacke (director of the South Australian Museum), publishes a notice alluding to the telegram and his own coincident announcement, and adding that his discovery of the eggs was made on the 25th of August last, in the mammary pouch (not in the uterus) of a living *Echidna hystrix*, received about the third of the same month from Kangaroo Island through Mr. A. Molineux." Dr. Haacke also remarks that "the old naturalists thought that the animals referred to were oviparous, but their belief had now been universally given up."

The South Australian Register of the 7th, contains an additional note, received as a telegram from Professor Liversidge, dated Sydney, New South Wales, Sept. 7th. This telegram states that Mr. W. H. Caldwell came to Australia for the express purpose of settling a long disputed question whether the Platypus (Ornithorhynchus) and Porcupine (Echidna) were born alive or hatched from eggs, and on August 29th, he telegraphed Professor Liversidge that the *Monotremata* (to which class the animals referred to belong) *are oviparous*, adding the request that the information be sent to the British Association, then in session at Montreal. The telegram adds that Mr. Caldwell is now in Northern Queensland, pursuing his investigations, at a station named Dangangald, two days journey from Camboon. Mr. Caldwell is the first recipient of the Balfour travelling Fellowship (established in honor of the late Professor Balfour) tenable for three years, he being "one of the most distinguished students of Natural History Cambridge University has produced, and especially capable in embryology. His proficiency led the British Association to commission him to try to solve the mystery of the Monotremes, and also to make further discoveries with regard to the Ceratodus. Mr. Caldwell "is likely to remain in Australia two years longer."

Mr. Theodore Gill, in *Science* for November 14th, reviews the history of the idea that the Monotremes were oviparous. He mentions that Geoffroy Saint-Hilaire, in 1829, published a paper, illustrated by a figure of an egg of the natural size, in the 18th volume of the Annales des Sciences Naturelles. It was received by him from Professor Robert E. Grant of London, who drew one of a nest of four obtained by a Mr. Holmes. Still earlier, the Rev. Dr. Fleming, in his Philosophy of Zoölogy (ii, 215) published in 1822, remarks that "if these animals are oviparous (and we can scarcely entertain a doubt on the subject, *as the eggs have been transmitted to London*), it would be interesting to know the manner of incubation"; and his belief led him to separate, in his classification of Vertebrates, the Monotremes from the Mammals. Mr. Gill states other facts bearing on the subject in his note.

7. *Organisms in Ice.*—Professor Leidy stated that there had been placed in his hands, for examination, a vial of water obtained

from melting ice which is used for cooling drinking-water. From time to time, among some sediment taken from a water-cooler, the gentleman had observed what he supposed to be living worms, which he suspected were introduced with the water into the cooler, and not with the ice. Upon melting some of the ice alone, the worms were still observed, and the water submitted for examination was some that was thus obtained. Professor Leidy was surprised to find a number of worms among some flocculent sediment, mainly consisting of vegetal hairs and other debris. Besides the worms there were also immature Anguillulas, and a number of *Rotifer vulgaris*, all living. It would appear that these animals had all been contained in the ice, and had been liberated on melting. It was an unexpected source of contamination of our drinking-water, that Professor Leidy had previously supposed to be very improbable. The little worms he was not familiar with. They belong to the family of Lumbricidæ, and may be an undescribed species of *Lumbriculus*. They are white, or colorless, from 4 to 6 millimeters long, by a third of a millimeter in thickness. The body is divided into thirty segments, bearing podal spines, which form four rows, with three in each fasciculus, and divergent. The spines are curved at the root, pointed at the free end, and measure 0·05 to 0·06 mm. long. The upper lip is blunt conical; the terminal segment truncate. There appears to be no distinct girdle, but the third, fourth and fifth segments contain capsuligenous glands and other organs pertaining to the sexual apparatus.

Several dead worms swarmed in the interior with large, ovate, beaked, ciliated infusorians measuring from 0·5 to 0·6 mm. long by 0·04 to 0·048 mm. broad.—*Proc. Acad. Nat. Sci. Philad.*, 1884, p. 260.

IV. Astronomy and Geodesy.

1. *Report of Observations made on the Expedition to Caroline Island to observe the Solar Eclipse of May* 6, 1883; by Winslow Upton. Washington, 1884. (Reprinted from vol. ii, of the Memoirs of the National Academy of Sciences.)—This report contains a statement of the results of observations undertaken to determine the longitude of Caroline Island, and also of observations on the meteorology of the island, and in addition a series of observations by three different methods on the Solar radiation. In regard to the last point, the author remarks:

"The following summary gives the conclusions derived from an examination of the results:

(1) The method of the black and bright bulb thermometers freely exposed in the air gives only an approximate determination of the solar intensity. This was expected, and is due to the constantly varying conditions of exposure, caused by the effect of the winds on convection currents.

(2) Violle's bulbs are affected by convection, but the effect is shown less than in freely exposed thermometers, on account of

the position of the thermometers within. The observations on the afternoon of May 2, when the air was almost perfectly still, show higher intensities than the corresponding times on other days, but the observations are not sufficient to indicate how much the results are influenced by this cause.

(3) The intensities by the conjugate thermometers seem also to be affected by the varying influence of convection, but in this case (and in the preceding also) direct experiments would give more information as to this effect than examination of these observations.

(4) The intensities by Violle's bulbs (see the curves) are smaller in the morning and greater in the afternoon than those by the conjugate thermometers. There is a marked difference in the time of the maximum readings, the Violle bulbs reaching the maximum one hour later than the conjugate thermometers. This shows that the former are sluggish in their action, and at any given time show the intensity not for that time but for a time already past many minutes. The sluggishness of the Violle bulbs was also indicated by the long time which was required after the passage of a cloud before their return to a normal condition.

(5) The curve corresponding to the intensities given by the conjugate thermometers represents the relative solar intensities as accurately as the observations permit for the period April 28 to May 3. It is impossible to give any mathematical estimate of the uncertainty of the numerical values which would be obtained from this curve. It is probable that the values are liable to an uncertainty of several hundredths, but not as great as a tenth. They may be accepted as the final values of the relative solar intensity obtained at Caroline Island. Expressed in terms of the 12·00 value they are as follows:"

Relative solar intensity at Caroline Island, April 28, *to May* 3, 1883.

Time.	Intensity.	Time.	Intensity.	Time.	Intensity.
A. M.		A. M.		P. M.	
7.00	0·47	10.30	0·94	2.00	0·93
7.30	0·57	11.00	0·97	2.30	0·90
8.00	0·66	11.30	0·99	3.00	0·87
8.30	0·73	12.00	1·00	3.30	0·82
9.00	0·80	P. M.		4.00	0·76
9.30	0·87	12.30	1·00	4.30	0·66
10.00	0·91	1.00	0·78	5.00	0·46
		1.30	0·96		

From the observed solar intensities was calculated the value of the "solar constant" as defined by Professor William Ferrel in his investigation of the theory of the conjugate thermometers, namely, the amount of heat received on a square centimeter of surface at the upper limits of the atmosphere expressed in small calories. The value obtained, reduced to the sun's mean distance, was

$$A = 2{\cdot}360.$$

Radiation observations were taken during the eclipse to determine what proportion of heat received by the earth was cut off by the concealing of the sun and also the shape of the curve representing the varying solar intensity. In regard to this subject the author states: "An examination of the observations and the results of the computation leads to the following conclusions:

(1) The readings of all the instruments were essentially the same at the close of totality, and agreed with the observed air temperature. This indicates that during the total phase no heat was received by the earth from the atmosphere, as far as these instruments allowed its measurement. It need hardly be said that the radiation instruments are not intended to show the effect of the heat of the corona, and are not sensitive enough for such refined measurement. Their use is to measure the effect of heat which is received from the sun and by reflection from the atmosphere—the heat which is a factor in causing vegetable growth; they do not claim a position as delicate physical instruments. The observations show that during the eclipse the amount of heat gradually diminished until practically none was received, and the temperature of night was attained.

(2) The maximum point of the curve in the first partial phase is at about 10.08 A. M., or four minutes after the first contact. This four minutes covers whatever tardiness the instruments possess, as well as the natural increase of solar heat in the morning, until it was overbalanced by the direct cutting off of a portion of the sun's heat. The minimum point of the curve is at about 11.40 A. M., or three minutes after the observed time of third contact. This time is somewhat uncertain, as from the nature of the case this portion of the curve is drawn arbitrarily, the intensities having become indeterminate. The second maximum is at 1.15 P. M., four minutes after the last contact was noted. The afternoon observations do not indicate as great intensities as the morning, as is further indicated by the computed diathermancy constants given below. The sky was observed to be quite hazy as the day advanced."

2. *New Form of Primary Base Apparatus;* by T. W. WRIGHT.—In Wright's *Treatise on the Adjustment of Observations* (Van Nostrand, New York), there is a description of a new form of primary base apparatus. The measuring bar is of metal packed in melting ice. The length of the bar will remain unchanged throughout the measurement as its temperature is constant, being that of melting ice. The same temperature can at any time be had at which to find the length of the bar in terms of the official standard of length. The apparatus might be constructed as follows: The measuring bar, a bar of steel 25^{mm} in diameter and 6^{m} in length, placed in a circular cast-steel tube $\frac{1}{8}^{m}$ in diameter, made stiff by bracing, but as light as possible. Along the top of this tube slots of about 75^{mm} in width would be cut to allow the introduction of ice around the bar. The hole for drainage would be at the center of the tube on the under side. For supports during the measurement two

trestles placed $1\frac{1}{2}^{m}$ from the ends would be best. Effects of flexure would be got rid of by having the graduation marks showing the length of the bar placed on the neutral axis of the bar. The reading microscopes, alignment apparatus, sector and level for determining the inclination of the bar during measurement, such as those made by Repsold for the U. S. Engineers. The mode of measurement the same as with the Repsold apparatus. The amount of computation necessary to reduce the measurements made in this way would be small in comparison with that required with the forms of apparatus at present in use. The scheme is entirely practicable in the United States, at least where ice is to be had everywhere at all seasons.

V. Miscellaneous Scientific Intelligence.

1. *Extracts of a letter to J. D. Dana, from* Dr. B. A. Gould, Director of the Observatory of the Argentine Republic, dated Cordoba, Oct. 4, 1884.—After fourteen years of an expatriation which I did not at the beginning intend should cover more than three, I see the end of the vast and expanded undertaking within reach. Its object has already been essentially attained, so that it would now appear that the end of the current year will see me either on my homeward way or very near to the commencement of the journey. Indeed I am cherishing the hope of personally welcoming the spring flowers of New England. . . . By this present time of writing, or very soon at any rate, you will receive four quarto-volumes of star-positions; and within about a month I hope to start a meteorological volume on its way. A huge mass of similar material will be left for the occupation of my successors in the two institutions. The manuscript of seven astronomical quartos I hope to leave ready for the press; and to bring with me for publication in the Northern hemisphere the General Catalogue of Southern Stars, which will complete the astronomical work. . . . .

2. *Sir William Thomson's Lectures on Molecular Dynamics.*—It is announced that a verbatim report of the eighteen lectures delivered by Sir William Thomson at the Johns Hopkins University, Baltimore, in October, 1884, is to be published from stenographic notes taken by Mr. A. S. Hathaway, and reproduced by the Papyrograph Plate Process. A bibliography of the subjects considered will also be given with the lectures. In all there will be about 350 pages, quarto. A few copies are offered for sale at $5.00 net. The edition is strictly limited to 300 copies, and orders therefore should be sent at once to the publication agency of the Johns Hopkins University, Baltimore, Md., U. S. A. Copies may also be procured from Messrs. Mayer & Müller, Französische Strasse 38, Berlin, W.; A. Hermann, 8 Rue de la Sorbonne, Paris; Trübner & Co., 57 Ludgate Hill, London.

INDEX TO VOLUME XXVIII.*

A

Absorption, atmospheric, *Langley*, 163.
by carbon dioxide, *Keeler*, 190.
Academy, National, Newport meeting, 406.
Smith medal, 77.
Affinity, chemical. *Langley*, 360, 437.
Africa, geology of South, 468.
Air, boiling point of, 150.
Alaska, glacier phenomena of, 74.
Anthemene, a hydrocarbon of chamomile, 149.
Association, American, Philadelphia meeting, 78, 303.
Physical papers before, 307.
British, Montreal meeting, 300.
Atmospheric absorption, *Langley*. 163.

B

Baines, A. C., The deflection of streams by terrestrial rotation, 434.
Baldwin, H., Orchids of N. England, 237.
Ball, J., Flora of North Patagonia, 157.
Barker, G. F., chemical abstracts, 146, 452.
British association, 300.
American Association, 303.
electrical exhibition at Philad., 386.
Barometric observations, reduction of, *Loomis*, 1, 81.
Bauermann, H., Text-book of Descriptive Mineralogy, 318.
Becker, G. F., mineral belts of the Pacific slope, 209.
Theory of faulting criticized, 348.
Becquerel, H., infra-red emission-spectra of metallic vapors, 457.
wave-lengths in the infra-red of the solar spectrum, 459.
Behr, H. H., Genera of Vascular Plants near San Francisco, 156.
Beryllium chloride, vapor-density of, 149.
crystalline form of, 148.
Bessey, C. E., The ...entials of Botany, 475.
Blake, F. H., vanadinite in Arizona, 145.
Blake, W. P., crystallized gold, 57.
columbite in the Black Hills, 340.
Blanford, W. T., fossils as a criterion of geological equivalency, 315.
Boissier's Flora Orientalis, 157.
Bohnensieg, G. C. W., Repertorium Annuum Literaturæ Botanicæ, 473.
Bostwick, A. E., influence of light on electrical resistance of metals, 133.
BOTANY—
Climate, influence of, on vegetation, *Buysman*, 354.
Flora Brasiliensis, 402.
Fungi, respiration and transpiration of, 241.
Hypopitys or Hypopithys, 238.
Lastarriæa, 76.
Lenticels, structure and function, 239.
Minnesota flora, 472.
Nectaries and water-glands, 240.
North American flora, *Gray*, 323.
Palms, structure and growth of, 239.
Patagonian flora, 157.
Plants, detection of nitrates and nitrites in, 239.
Trilisa, 403.
See further under GEOLOGY.
Brezina, A., Krystallographische Untersuchungen, 75.
Browne, A. E., Becker's theory of faulting, 348.
Bureau of Scientific Information, 320.
Buysman, influence of sea and continental climate on vegetation, 354.

C

Campbell, J. L., geology of the Blue Ridge, 221, 242.
Carbonic oxide, boiling point of, 150.
absorption by, 190.
Carhart, H. S., electromotive force of a Daniell cell, 374.
Chamberlin, T. C., terminal moraine of second glacial epoch, 228.
Chatard, T. M., mineralogical notes, 20.
Cheesman, L. M., measurement of electric currents, 117.
Chemical affinity, *Langley*, 360, 437.
Clarke, C. B., East Indian Species of Cyperus, 75.
Clarke, F. W., mineralogical notes, 20.
Cold, see *Temperature*.
Collett, J., Indiana Geological Report, 314.

*This Index contains the general heads BOTANY, GEOLOGY, MINERALS, OBITUARY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

Color impressions, duration of, *Nichols*, 243.
and atomic weight of compounds, 453.
Comoy, Études pratique sur les marées fluviales, 228.
Congress, International, at Washington, 405.
Cooke, J. P., Jean-Baptiste-André Dumas, 289.
Crystallization, strain connected with, 461.
Cyanides, production of, from trimethylamine, 147.

D

Dana, E. S., on herderite, 318.
Dana, J. D., terminal moraine of the second glacial epoch, 228.
terminal moraine of Penn., 231.
the southward ending of a great synclinal in the Taconic, 268.
Taconic slates, 311.
the Azoic system, 313.
Cortlandt hornblendic and augitic rock, 384.
origin of bedding in so-called metamorphic rocks, 393.
making of limonite ore-beds, 398.
the decay of quartzyte, 448.
Davis, W. M., gorges and waterfalls, 123.
distribution and origin of drumlins, 407.
Whirlwinds, Cyclones and Tornadoes, 151.
Dawson, Prehistoric man in Egypt and Syria, 158.
Deep-sea fauna, 319.
Derby, O. A., flexibility of itacolumite, 203.
gold in Brazil, 440.
Diller, J. S., fulgurite from Mt. Thielson, 252.
octahedrite as an alteration product of titanite, 234.

E

Earthquake in Middle and Eastern States, 242.
of Ischia, 312.
Eastman, I. R., new meteorite, 299.
Eclipse, see *Sun*.
Electric battery, observed and calculated force of, 452.
current, silver voltameter for measurement of, 224.
currents, measurement of rapidly alternating. *Cheesman*, 117.
of earth's surface, 71.
Electrical congress, results of, 71.
exhibition at Philadelphia, 225.
at Paris, 310.
Electricians, national conference of, 386.
Electricity, atmospheric, 70.
earth currents, 71.
resistance of metals, influence of light on, *Bostwick*, 133.
Electrometric measurements, 390.
Electromotive force of a Daniell cell, *Carhart*, 374.
Elkin, W. L., Heliometer determinations of Stellar Parallax, 404.
Explosives, modern high, 310.

F

Ford, S. W., Primordial fossils in Stuyvesant, N. Y., 35.
age of rocks near Schodack Landing, 206, 242.
Forel, F. A., Glacial Studies, 400.
Fossil, see GEOLOGY.
Fulgurites from Mt. Thielson, *Diller*, 252.

G

Galenite, synthesis of, 455.
Galton, F., Life-History Album, 78.
Gardiner, W., water-glands and nectaries, 240.
Gas analysis under greatly diminished pressure, 454.
Gases and vapors, diffusion of, 70.
Geological Congress, third session of the, 78, 318.
GEOLOGICAL REPORTS AND SURVEYS—
Indiana, 314.
Minnesota, 155, 316, 322, 472.
New York, 234.
Pennsylvania, 231, 234, 396, 406, 470.
United States, 20, 228, 401, 462.
GEOLOGY—
Africa, geology of South, 468.
Age, fossils as a criterion of, 315.
Apatite of the Canadian rocks, *Vennor*, 74.
Archæopteryx, the Berlin, 465.
Argillite of Newfoundland, *Wadsworth*, 101.
Azoic, subdivisions of, *Whitney*, 313.
Basalt of Newfoundland, *Wadsworth*, 94.
Bedding, origin of, *Dana*, 393.
Bitumens, origin of, *Peckham*, 105.
Blue Ridge, near Balcony Falls, *Campbell*, 221.
Bowlder clays of Chicago, 317.
Canadian rocks, apatite of, *Vennor*, 74.
Centre County, Penn., 396.

GEOLOGY—
Ceratosaurus, united metatarsals of, *Marsh*, 161.
Coal plants of Mazon creek, 314.
Coals, structure of Carboniferous, 467.
Corals, Carboniferous of Scotland, 316.
Cortlandt hornblendic rock, *Dana*, 384.
Cuba, iron-ores of, *Kimball*, 416.
Drift of Minnesota, 316.
Drumlins, distribution of, *Davis*, 407.
Ecca beds of South Africa, 468.
Faulting, Becker's theory of, *Browne*, 348.
Fossils as a criterion of geological equivalency, 315.
Primordial, in Stuyvesant, *Ford*, 35.
Glacial Epoch, terminal moraine of second, 228.
moraine in Pennsylvania, 231.
deposits of Long Island, 230.
period and the Niagara River, *Wright*, 32.
rivers of Maine, 152.
studies, 400.
Glaciation south of the terminal moraine, supposed, *Lewis*, 276.
Gold in Brazil, *Derby*, 440.
Granite, origin of Tuscan, *Lotti*, 155.
Insects, Triassic, *Scudder*, 199.
Iron-ores of Cuba, *Kimball*, 416.
Itacolumite, flexibility of, *Derby*, 203.
Kame rivers of Maine, *Stone*, 152.
Kaolin from quartzyte, 449.
Lake Superior, copper-bearing rocks of, 462.
Limonite ore beds, *Dana*, 398.
Long Island, moraine deposits of, 230.
Metamorphism, *Lehmann*, 392.
Mineral belts of the Pacific slope, *Becker*, 209.
Moraine, see *Glacial Epoch*, above.
Myriapods, Carboniferous, 470.
Namaqualand schists, 468.
Newfoundland, rocks of, *Wadsworth*, 94.
Niagara River and the Glacial period, *Wright*, 32.
Nickel ore in Nevada, *Newberry*, 122.
Ore beds of Centre Co., Penn., 397.
of Newfoundland, *Wadsworth*, 102.
Ores, deposition of, *Newberry*, 465.
Phosphates of North Carolina, 75.
Quartz deposit made at the ordinary temperatures, 448, 466.
Quartzyte, decay of, *Dana*, 448.
Rocks of Newfoundland, *Wadsworth*, 94.
origin of crystalline, *Hunt*, 72.

GEOLOGY—
Sand, formation of, *Dana*, 448.
miniature domes in, 469.
Sandstone, surface consolidation by atmospheric action, *Wadsworth*, 466.
Streams, deflection of, *Baines*, 434.
Taconic slates, age of, *Hall*, 311.
range, synclinal in, *Dana*, 268.
Tertiary of Eastern and Southern United States, 316.
shells, *Meyer*, 154.
Texas, Paleozoic of Central, *Walcott*, 431.
Waterfalls, gorges and, *Davis*, 123.
Gilbert on the deflection of streams by terrestrial rotation, criticized by *Baines*, 434.
Gill, D., Heliometer determinations of Stellar Parallax, 404.
Gill, T., Principles of Zoogeography, 241.
Glacier phenomena of Alaska, 74.
see also under GEOLOGY.
Gold, see MINERALS.
Goodale, G. L., botanical notices, 239, 474.
Gorges and waterfalls, *Davis*, 123.
Gould, B. A., Report upon the unification of Longitudes, 321.
Letter from, 480.
Gray, A., memorials of Engelmann and Heer, 61.
botanical notices, 75, 155, 237, 402, 472.
George Bentham, 319.
North American flora, 323.
Synoptical Flora of North America, 237.
Gulf of Mexico, dimensions of, 320.
Gumbel, K. W. von, Geologie von Bayern, 317.

H

Hall, J., Monomyaria of the Upper Helderberg, etc., noticed, 234.
the Hudson River age of the Taconic slates, 311.
Hazen, H. A., tornadoes, 181.
Heap, D. P., International Exhibition of Electricity, 310.
Helmholtz's dispersion theory, 457.
Herderite, composition of, 318, 401, 471.
Hitchcock, R., causes of variation, 49.
Hooker, J. D., Student's Flora of the British Islands, 238.
Hunt, T. S., origin of crystalline rocks, 72.

I

Ice, living organisms in, *Leidy*, 476.
Invilliers, E. V. d', Geology of Centre Co., Penn., 396.

Iron, meteoric, from Texas, *Mallet*, 285.
Irving, R. D., paramorphic origin of hornblende of the crystalline rocks of the northwest, 464.
Copper-bearing rocks of Lake Superior, 462.
Ischia, earthquake of, 312.
Itacolumite, see GEOLOGY.

J

Jackson, A. W., on colemanite, 447.
James, T. P., Mosses of North America, 155.
Johnson, H. A., microscopic organisms in bowlder clays of Chicago, 317.
Jones, T. R., Geology of South Africa, 468.
Joule, J. P., Scientific papers of, 151.

K

Keeler, J. E., absorption of radiant heat by carbon dioxide, 190.
Kimball, J. P., specular iron-ores of Santiago de Cuba, 416.
Kunz, G. F., chlorophane from Amelia County, Virginia, 235.

L

Lactosin, a new carbohydrate, 149.
Langley, J. W., chemical affinity, 360, 437.
Langley, S. P., amount of atmospheric absorption, 163, 242.
Lehmann, J., Untersuchungen über die Entstehung der altkrystallinen Schiefergesteine, 392.
Leidy, J., organisms in ice, 476.
Lesley, J. P., ore beds of Centre Co., Penn., 397.
Lesquereux, L., Mosses of North America, 155.
Coal Flora of Pennsylvania, 470.
Lewis, H. C., Pennsylvania Geological Report, 231.
supposed glaciation south of the terminal moraine, 276.
Light, method of determining the standard of, 150.
effect upon electrical resistance of metals, 133.
Lightning tubes, *Diller*, 252.
Lindenkohl, A., dimensions of the Gulf of Mexico, 320.
Linnæan Society of New York, 319.
Lloyd, J. U., Drugs and Medicines of North America, 474.
Loomis, E., contributions to meteorology, 1, 81.
Lotti, B., origin of Tuscan granite, 155.

M

Macfarlane, J., Geological Railway Guide, 471.
Mackintosh, J. B., composition of herderite, 401.
Magnetic forces, measurement of by hydrostatic pressure, 223.
polarity and neutrality, 309.
Magnetization, change in temperature from, 225.
Mallet, J. W., meteoric iron from Texas, 285.
Marsh gas, preparation of, 148.
Marsh, O. C., united metatarsal bones of Ceratosaurus, 161.
Martin, H. N., Handbook of Vertebrate Dissection, 77.
Matthew, G. J., Fauna of the St. John Group, New Brunswick, 74.
Metallic vapors, infra-red emission-spectra of, 457.
Meteorite, new, *Eastman*, 299.
Meteorites, origin of, 470.
Meteorological Society, New England, 159.
Meteorology, contributions to, *Loomis*, 1, 81.
Meyer, O., notes on Tertiary shells, 154.
Mineralogist and Antiquarian, 406.
MINERALS—
Aimafibrite, 236.
Aimatolite, 236.
Allanite, *Clarke* and *Chatard*, 21.
Alunogen, *Clarke* and *Chatard*, 24.
Annabergite, 122.
Apatite, 74.
Beryl, *Clarke* and *Chatard*, 25.
alkalies in, *Penfield*, 25.
Cassiterite, *Clarke* and *Chatard*, 25.
Chlorophane from Virginia, *Kunz*, 235.
Cimolite, *Clarke* and *Chatard*, 23.
Colemanite, *Jackson*, 447.
Columbite, *Blake*, 340.
Damourite, *Clarke* and *Chatard*, 21.
Gold, crystallized, *Blake*, 57.
in Brazil, *Derby*, 440.
Goyazite, 237.
Halloysite, *Clarke* and *Chatard*, 23.
Halotrichite, *Clarke* and *Chatard*, 24.
Herderite, 318, 401, 471.
Hornblende, paramorphic origin of, *Irving*, 464.
and pyroxene, *Williams*, 259.
Hyalite, *Clarke* and *Chatard*, 25.
Jade and pectolite, *Clarke* and *Chatard*, 20.
Kaolin from quartzyte, *Dana*, 449.
Manganostibiite, 236.
Margarite, *Clarke* and *Chatard*, 22.
Niccolite, *Newberry*, 122.

MINERALS—
Octahedrite, *Diller*, 234.
Pectolite, *Clarke* and *Chatard*, 20.
Prochlorite, *Clarke* and *Chatard*, 24.
Pyroxene and hornblende, *Williams*, 259.
Saussurite, *Clarke* and *Chatard*, 21.
Stibnite from Japan, 402.
Tantalite, *Schæffer*, 430.
Titanite, *Diller*, 234.
Tourmaline, 456.
Utahite, 236.
Vanadinite in Arizona, *Blake*, 145.
Vivianite, *Clarke* and *Chatard*, 25.
Minnesota Geological Report, Crustacea, 322.
Moale, W. A., Hand-book of Vertebrate Dissection, 77.
Moseley, H. N., Deep-sea Fauna, 319.

N

National Dispensatory, 322.
Newberry, J. S., the deposition of ores, 406, 465.
Newberry, S. B., nickel ore from Nevada, 122.
Newton, H. A., astronomical notice, 404.
Niagara River, see GEOLOGY.
Nichols, E. L., duration of color impression on the retina, 243.
a study of pigments, 342.
Nitrates, detection of, in plants, 239.

O

OBITUARY—
Bentham, G., 319.
Dumas, J. B. A., 289.
Engelmann, G., 61.
Heer, Oswald, 67.
Hochstetter, F. von, 160.
Lavallée, Alphonse, 75.
Smith, Robert Angus, 79.
Ocean, deep-sea fauna, 319.
deposits, *Verrill*, 379.
Ohm, value of the, 71.
Optics, physiological, *Nichols*, 243.
Ores, deposition of, *Newberry*, 465.
see also under GEOLOGY.
Oxygen, boiling point of, 150.

P

Parallax, stellar, 404.
Parker, T. J., A Course of Instruction in Zootomy, 76.
Parlatore, F., Flora Italiana, 403.
Parry, C. C., Chorizanthe, 76.
Peckham, S. F., origin of bitumens, 105.
Penfield, S. L., occurrence of alkalies in beryl, 25.
Perlitic structure, development of, 461.
Phillips, J. A., Treatise on Ore Deposits, 406, 469.
Phillips, W. B., North Carolina Phosphates, 75.
Photographing colored objects in their natural shades, 223.
Pickering, E. C., light of comparison stars for Vesta, 17.
Annals of Observatory of Harvard College, 319.
Pigments, a study of, *Nichols*, 342.
Planet Vesta, light of comparison stars for, *Pickering*, 17.
Plants, see BOTANY.
Polariscope, new form of, 456.
Polarization, electro-magnetic rotation of plane of, 456.

R

Rath, G. vom, Geologische Briefe aus America, 401.
Rayleigh, Presidential address, 300.
Ridley, H. L., African Cyperaceæ, 75.
Rivers, deflection of, *Baines*, 434.
Rockwood, C. G., earthquake in Middle and Eastern States, 242.
Russell, I. C., Geological History of Lake Lahontan, 401.
Rutley, F., strain connected with crystallization, 461.

S

Schæffer, C. A., a new tantalite locality, 430.
Scudder, S. H., Triassic insects, 199.
Carboniferous Cockroaches and Myriapods, 470.
Sea, see *Ocean*.
Smith, S. I., crustacea of the Albatross dredgings, 53.
zoological notices, 76.
Society, Meteorological, of New England, 159.
Royal of Canada, 159.
of New South Wales, 160.
Solar, see *Sun*.
Solvents, law of solidification of, 146.
Spectra of metallic vapors, 391, 457, 459.
Stokes, A. C., new fresh-water infusoria, 38.
change of generic name Solenotus to Notosolenus, 158.
Stone, G. H., the kame rivers of Maine, 152.
Storer, F. H., shell- and rock-boring mollusks, 58.
obituary of R. A. Smith, 79.

Strasburger, Das Botanische Practicum, 474.
Streams, deflection of, *Baines*, 434.
Sun, infra-red spectrum of, 391, 459.
eclipse observations, 477.
Swan incandescent lamp, radiation of, 225.

T

Tait, P. G., Light, noticed, 310.
Temperatures, production of low, 224.
Thomas, B. W., microscopic organisms in bowlder clays of Chicago, 317.
Thomson, J., corals of the Carboniferous of Scotland, 316.
Thomson, W., Presidential address, 302.
Lectures on Molecular Dynamics, 480.
Thurston, R. H., Materials of Engineering, 405.
Tides in rivers, 228.
Toluene, action of amyl-chlorides on, 455.
Tornadoes, *Hazen*, 181.
Tourmaline, conductivity of, for heat, 456.
Trowbridge, J., physical notices, 70, 150, 223, 390, 456.
physical papers read before the American Association, 307.

U

Underwood, L. M., Catalogue of North American Hepaticæ, 403.
Upham, W., Minnesota Geological Report, 316.
Catalogue of the Flora of Minnesota, 472.
Upton, W., Caroline Island Eclipse Expedition, 477.

V

Vapor densities, determinations of, 390.
Variation, causes of, *Hitchcock*, 49.
Vasey, G., Agricultural Grasses of the United States, 403.
Vennor, H. G., apatite of the Canadian rocks, 74.
Verrill, A. E., marine fauna of New England, 213.
marine fauna and deep-sea deposits, 378.
Vesta, comparison stars for, *Pickering*, 17.
Vom Rath, Geologische Briefe aus America, 401.

W

Wadsworth, M. E., rocks of Newfoundland, 94.
the Azoic system, 313.
atmospheric action on sandstone, 466.
Lithological Studies, 470.
Wahl, W. H., the Electrical exhibition at Philadelphia, 225.
Walcott, C. D., Paleozoic rocks of Central Texas, 431.
Waterfalls, gorges and, *Davis*, 123.
Watts, H., Manual of Chemistry, 72.
Wave-lengths in the infra-red of the solar spectrum, 391, 459.
Waves, tidal, in rivers, 228.
Weisbach, A., herderite, 318.
Wethered, E., structure of Carboniferous coals, 467.
Whitney, J. D., the Azoic system and its subdivisions, 313.
Williams, G. H., paramorphosis of pyroxene to hornblende, 259.
metamorphism, 392.
Winchell, N. H., Minnesota Geological Report, 155, 316.
Winkler, analysis of herderite, 318.
Wright, G. F., Niagara River and the glacial period, 32.
Wright, T. W., Adjustment of Observations, 405.
New Form of Primary Base Apparatus, 479.

Z

Zoology—
Crustacea of the Albatross dredgings, *Smith*, 53.
Echidna, eggs of, 475.
Fauna of deep-sea, 319.
Infusoria, new, *Stokes*, 38.
Marine fauna of New England, *Verrill*, 213, 378.
Mollusks, boring, *Storer*, 58.
Notosolenus, *Stokes*, 158.
Ornithorhynchus, eggs of, 475.
Rotifers in ice, 477.
Solenotus, *Stokes*, 158.
Sponge spicules, siliceous, 76.
Variation, causes of, *Hitchcock*, 49.
Worms in ice, 477.
Zoogeography, *Gill*, 241.
See further under Geology.